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GERMAN PHYSICIANS TO THE CROWN PRINCE.

WE feel that we owe to our readers an account of those who have offered assistance to the Crown Prince during his illness and have tried to lighten his sufferings. When made acquainted with the lives and education of these men, the reader will understand that everything within the power and knowledge of man has been done, and will gain new hope for the recovery of the royal patient.

Dr. A. Wegner is physician to the Crown Prince, and has treated him exclusively until within the past year. He is a man of sixty-eight, was born in Berlin and graduated from the Friedrich Wilhelms Institute of the Berlin University as military surgeon. He completed his medical education by studying in London, Edinburgh, and Paris. From the position of Oberstabartz he was appointed Physician General of the third army corps, and for the past seven years he has held the position of directing surgeon of the Gardecorps. Dr. Wegner, who for a long time has held the office of examiner in advanced medical examinations, is known as a scientific as well as a practical man. Since 1852 he has been physician to the Crown Prince, whom he accompanied on most of his long journeys; and since 1858, after the marriage of the Crown Prince, he has also been physician to his household. Although the special physician of the Crown Prince, who had enjoyed his confidence for thirty-five years, understood the constitution of the illustrious patient better than any one else, still the local nature of the disease required the skill of a specialist. It was thought best to consult some celebrated clinicist, and Prof. Gerhardt was selected.

Prof. Dr. Karl Gerhardt was born in Speier in 1833, and was a pupil of Bamberger and Rinecker, whose lectures in Würzburg he attended from 1850 to 1856. In 1858 and 1859 he was assistant to Griesinger in Tübingen; since 1861 he has been professor of the clinic of internal medicine in Jena; and since 1872, professor at the Würzburg High School. Like the other coryphei of the Berlin medical faculty, Virchow and Von Biergmann, he was called from Würzburg to Berlin, where he has conducted the second medical clinic in the "Charité" since the death of Frerich. By his numerous articles he has gained a reputation for himself in the branch of internal medicine; that is, in physical diagnosis, and the science of children's diseases and diseases of the larynx. He is one of the most celebrated and scientific clinicists in Germany. It was Prof. Gerhardt who made the first attempt to remove the growth in the Crown Prince's throat by the use of galvano-cautery. The obstinate return of the growth caused him to consider the disease of a malignant nature and to propose that Prof. Dr. Tobold, the laryngologist, should be consulted.

Adalbert Tobold, who was born in Flatow, West Prussia—he is now sixty years old—is one of the oldest laryngologists. As long ago as 1856 he chose laryngology, rhinology, and the pathology of the lungs as specialties, and fitted himself in these branches at the Berlin University. He also developed a great ability as a writer; and, furthermore, he enriched the methods of object teaching in his branches by excellent drawings showing diseased conditions of the larynx; and he exhibited, among other things, a fine collection of reproductions in plaster of diseases of the larynx at the convention of great naturalists in Berlin. Tobold's opinion coincided with those of the above-named physicians, and the Berlin doctors advised an external operation.

The celebrated Berlin surgeon, Prof. Dr. Von Bergmann, who was now called in, proposed the removal of part of the larynx as the only sure cure in the case. Ernst Von Bergmann studied in Dorpat, Vienna, and Berlin. In 1882 he was called from the Würzburg High School—where he had been professor of surgery and director of the surgical clinic at the university—to fill Langenbeck's place in Berlin. As all believers turn to Mecca, so cripples and sufferers from all parts of the world flock to his clinics in Ziegelstrasse. In these rooms one may hear all the languages of Europe, besides many that are not European, spoken by patients whose last hope lies in the help they expect to gain from the celebrated surgeon, for Bergmann, so they say, "can perform any operation." From time to time stories of the operations performed by this busy man reach the public, stories which border on the miraculous. Besides the fame which he owes to his sure and skillful hand, he possesses great scientific knowledge, particularly in regard to affections of the brain. Of his numerous writings we will mention only those which have appeared in the "Zeitschrift der Wurzburger Medizinisch-physiologischen Gesellschaft" on the "Extirpation of the Larynx." This man, who is now fifty-one years old—and we may mention in passing that he is a man of fine appearance—has been loaded with innumerable titles and honors, but the greatest of these is his appointment by his German colleagues to the presidency of the German Society of Surgery.

As is well known, the operation proposed by Von Bergmann in May was not performed, and the great English laryngologist, Dr. Morell Mackenzie, who was now called to attend the royal invalid, made another attempt to remove the growth by an internal operation. In order to discover the nature of the swelling, the English specialist removed small portions of the larynx and sent them to Prof. Virchow for examination.

Virchow is the most celebrated investigator of such subjects. He is the originator of "Cellular Pathology," and on his work which bears that name is based the entire medical conception of our time. He is also the author of the present science of tumors. Formerly, abnormal fluids and injurious nervous influences played the mystic role of the final cause of all diseases, but now Virchow, supported by his numerous microscopical investigations, has proved that we have to deal with the diseased condition of the cells. Diseased growths of the different cells cause different tumors, abnormal nourishment of the cells causes inflammation, etc. Rudolph Virchow—who was born at Schivelbein, Pomerania, in 1821—studied in Berlin, was made professor in Würzburg in 1849, and in 1856 was called to the Berlin High School, whose medical faculty owes much of its renown to him. In 1847 he was appointed Geheimen Medizinalrat. We take it for granted that every one knows all that Virchow has done for the other branches of medicine, viz., pathological anatomy, anthropology, hygiene, etc.

Unfortunately, Mackenzie's treatment proved unsuccessful. As every one knows, by the wish of the English physician, two German specialists were called to a consultation at San Remo. The physicians chosen were Prof. Schrötter and Dr. Krause,

DR. A. WEGNER (Berlin), Physician General of the Gardecorps and Physician to the Crown Prince.

PROF. DR. KARL GERHARDT (Berlin).

PROF. DR. LEOPOLD V. SCHROTTER (Vienna.)

PROF. DR. ERNST V. BERGMANN (Berlin), Private Medical Adviser.

PROF. DR. RUDOLF VIRCHOW (Berlin), Private Medical Adviser.

DR. HERMANN KRAUSE (Berlin).

PROF. DR. ADALBERT TOBOLD (Berlin).

DR. MORIZ SCHMIDT (Frankfurt a. M.).

THE MEDICAL COUNSELORS OF THE CROWN PRINCE OF GERMANY.

who were joined, by the order of the German Emperor, by Dr. Moriz Schmidt, of Frankfort. These three physicians were obliged to confirm the original unfavorable diagnosis of the Berlin physicians, but they, with Mackenzie, arranged a plan for the further treatment of the patient.

Prof. Leopold Schrötter, who was born in Graz in 1837, is an authority of the first rank in laryngology. He was a pupil of Schuhs and Skodas, and has been professor at the Vienna High School since 1875. Since 1881 he has been chief physician of the General Hospital in Vienna. He is known as an experienced, industrious, and energetic physician, and has made a name for himself by his numerous writings on subjects relating to his specialty. A text book of his on diseases of the larynx has just appeared.

Dr. Moriz Schmidt, who was probably appointed by suggestion of the Berlin physicians, is forty-nine years old. After tours in England, France, and Holland, he settled at Frankfort-on the-Main as a specialist for throat and lung diseases, and there enjoyed a high reputation as a skillful operator. He was the first to declare that consumption of the larynx could be cured, and lately has been specially noted for his treatment of the disease by tracheotomy, for, according to his theory, rest of the larynx is a necessary condition for the favorable progress of the healing process.

Dr. Hermann Krause, the youngest of the consulting physicians, was privatdozent (tutor) at the Berlin University three years ago, and he opened a private polyclinic for the study of diseases of the larynx and nose, which has been largely attended by physicians and students. He was born in Schneidemühl in 1848, studied in Berlin and Breslau, and finally devoted some years to special studies, chiefly under Schrötter, in Vienna. A number of scientific articles on the diseases of the nose and larynx bear witness to his earnest work. To physicians he is known by his microscopic investigations in ozoena as well as by his works entitled "The Laryngal Center in the Cerebral Cortex" and "Reflex Contraction of the Muscles of the Larynx." On the practical side there is also much to be said in his favor. Of late years he has inaugurated a complete reform in the treatment of consumption of the larynx by the use of lactic acid. He has also invented several instruments which are very useful in the treatment of the larynx. Dr. Krause has a sympathetic, winning manner, and soon gained the confidence of his royal patient, who desired him to remain at San Remo, where he is assisted by two other skillful physicians. These are Dr. Schrader, the representative of Dr. Wegner, who is extremely experienced and skillful in the treatment of wounds; and Dr. Bramann, first assistant of Prof. Von Bergmann, a man of about thirty-three, who enjoys an excellent reputation as an operator, and has great experience and skill, specially in the department of tracheotomy.

Considering the skill of the men who are now gathered about the patient at San Remo, the German people may look forward with confidence to the future of the Crown Prince, waiting quietly for what may be dealt out by a merciful Providence.—*Ueber Land und Meer; Deutsche Illustrirte Zeitung.*

[Continued from SUPPLEMENT, No. 627, page 10016.]

THE QUARANTINE SYSTEM OF LOUISIANA.

METHODS OF DISINFECTION PRACTICED.

By JOSEPH HOLT, M.D., President Board of Health, State of Louisiana.

APPLICATIONS OF DRY AND MOIST HEAT.

WHILE these two processes of sanitary treatment of the vessel are going on, all bedding, ship's linen, cushions, mattresses, flags, mosquito nets, curtains, carpets, rugs, all personal baggage and wearing apparel of whatever description, are removed from the ship to a commodious building in close proximity (see Fig. 5), in which these articles are treated by moist heat at a temperature of not less than 230° Fahrenheit. The apparatus for this work consists in a steel forty horse power steam boiler (see Fig. 8), for supplying steam to a superheating chamber a few feet distant, and which I will now describe. (See Figs. 6 and 7.) The dimensions of this chamber, taken interiorly, or inside measure, are 60 feet long, 11 feet wide, and 7 feet high. The framework is composed of 3×3 inch seasoned pine lumber, joined as in the construction of a frame house. Upon the outside of this framework (and corresponding to weatherboarding in the case of a house) is nailed tongued and grooved flooring material three-fourths of an inch thick by six inches wide. The inside or interior of the ends, rear and top of the chamber is ceiled with the same material, and a flooring of the same is also laid. Upon these interior surfaces is tacked heavy "Russian hair cloth or felting," and upon this, at intervals of three feet, are nailed parallel strips of wood 1½×2 inches, and, in turn, upon these strips is fastened another sheathing or ceiling of flooring plank, as already described. This secures an air space between the hair cloth and inner ceiling. Upon this now smooth interior surface of wood is finally tacked and held in place by very broad-headed nails, or, better, by nails supplied with tin disks or washers, a double layer of "asbestos building felt," well lapped and securely tacked, thus rendering the interior of the chamber fire proof.

By the foregoing described construction it will be seen that the walls of the chamber, which are eight inches in thickness, consist of seven non-conducting media. First, the outer layer of planking; second, three inches of air space; third, an inner ceiling of planking; fourth, one inch thickness of "Russian hair cloth;" fifth, one and one-half inch air space; sixth, a third layer of three-fourth inch planking; seventh, a double layer, or interior lining, of heavy asbestos felting. The front wall is divided into forty panels, eighteen inches wide each (see Fig. 6), which represents that number of racks contained within the chamber. Upon the bars of these racks the clothing, etc., is hung for exposure to disinfection by moist heat. (See Fig. 7.) These racks are constructed with a front and rear panel united by horizontal bars, six to each side. Each rack is suspended overhead, on traveling rollers, upon an iron rod which extends from the rear wall of the chamber to a support ten feet in front of the chamber, the rod, therefore, being twenty feet in length. By this arrangement overhead, the racks may be drawn out and pushed in with facility, thus avoiding tracks or rods on the floor obstructing the movements of employes. When drawn out the full length of ten feet, the rear panels of the rack securely close the chamber, as do the front panels when the racks are pushed in, thus admitting of the heating of the chamber during the time of hanging the articles of clothing, etc., on the rack bars preparatory to disinfection.

For this admirable device, and, indeed, for the entire skeleton of the superheating chamber, including the dry heat double steam coils, we are indebted to the Troy Laundry Machine Company, Chicago, Ill. We have found the purchase of this apparatus, constructed to include certain of our specifications, to be the most economical and satisfactory we could have desired. The interior surface of each front panel is lined with a layer of Russian hair cloth, over which is applied a double layer of asbestos felting. At intervals of seven and one-half feet a bulkhead of one inch tongued and grooved flooring is constructed, subdividing the chamber into eight compartments. These bulkheads, or partitions, are made fire proof by a covering of a double layer of asbestos felting, the object of this arrangement being to provide against the spread of fire in the event of its occurrence. In addition to this provision, there is a double lead of one inch fire hose connected with a steam pump near the boiler, and at all times ready, within fifteen seconds' notice, to turn on two streams of water upon any rack on which fire might have originated.

These minute specifications concerning provision against fire are particularly appreciated by ourselves. It cost us two fires and the destruction of a large amount of property to learn a lesson which experience alone could teach. Lacking experience and precedent, these accidents could not have been foreseen, and therefore could not have been provided against. They were the result of an underrating, and failure to appreciate the prodigious force the contrivance invented placed at our will to invoke. Under the present arrangement, including early use of free steam, fire is hardly possible, but if it should occur we are prepared to draw out instantly the burning panel, to strip it of clothing, and to put out the fire. With reasonable care and watchfulness on the part of the employes, there need be absolutely no danger of loss by fire. The superheating of this chamber is so provided as to furnish at will dry or moist heat, or both, and by a turn of the hand a temperature of 300° F. can be obtained. Within and at the end of this chamber, next to and connected with the boiler, are two manifolds, one above the other, to which is connected a system of forty-five three-quarter inch steam pipes (aggregating 5,509 lineal feet), placed horizontally near the floor of the chamber, running its full length, and supplied with a "bleeder" for conveying off the water of condensation. This double coil furnishes the dry heat. Above and in close proximity to this system of pipes is extended a horizontal screen of galvanized iron one-half inch mesh, to catch, and so prevent the coming in contact with the superheating pipes, any article falling from the racks. (See Fig. 7.)

The moist heat is supplied by a one inch steam pipe laid centrally in the midst of the above described dry heat pipes and running the entire length of the chamber, constituting a steam main, connected with the boiler, and controlled, as the others, by a ball valve on the outside. This pipe is perforated by eighty one-twelfth inch holes, so placed as to furnish steam to each rack. During the time of hanging the articles of clothing, etc., on the racks, the dry heat is turned on and the temperature raised to about 190° F., made known by a thermometer having a large mercurial column, and suspended near the center of the chamber, working on a slide or traveling rod in such a manner, when it is desired to make a reading, as to allow of being drawn forward (by a cord extending outside) to a long narrow pane of glass set in the panel. This thermometer should have a scale of at least 275° F. As each rack is filled it is put back into place. By the time the last of the articles have been hung on the racks, the entire mass of the material within the chamber has attained a temperature between 190° and 200° F., when free steam is turned on. The thermometer speedily rises to a point varying between 230° and 240° F., at which it is maintained for a period of twenty minutes. The steam pressure in the boiler, at the beginning of this process, registers between 100 and 110 pounds by the steam gauge. At the end of the process of blowing in steam the pressure will have fallen to about sixty pounds. The steam is now entirely cut off from the chamber, the racks are drawn out and their contents removed.

During the process of steaming, every article is perceived to be saturated and intensely hot, the steam freely permeating to the interior of mattresses, double blankets, etc., but so great is the heat in the texture of the fabrics as to immediately expel all moisture upon drawing the racks and exposure to the open air. Shirts, collars, etc., instantly assume the crisp dryness they possessed before exposure, losing the musty smell of long packing in a trunk. Silks, laces, the most delicate woolen goods, show no signs of injury whatever from the treatment. Of course, articles of leather, rubber, and whalebone would be injured by the heat, and are therefore disinfected with the mercuric solution and not permitted to go into the heated chamber. Time required to charge chamber with apparel for disinfection, thirty minutes; time required for moist heat, twenty minutes; for removal of articles, fifteen minutes. A large steamship, particularly a passenger vessel, may require two or three charges of the chamber. Amount of coal consumed, from two to four barrels per vessel. In the summer of 1885 we devised and put up a chamber of the above general plan, but wholly inadequate, as to the size, for the requirements of our service. This was replaced by one operating on the same principle, but fifty feet long and supplied with a twenty horse power boiler, which latter proved too small for rapid work. This apparatus was burned last spring. Our present chamber and supply boiler are of the dimensions given in the appended plates.

We prepared the plans of the foregoing described apparatus during the summer of 1884. Obtaining a liberal appropriation of $30,000 from the State legislature for the avowed purpose of establishing a new system of quarantine through the elaborations of purely experimental work, and thoroughly indorsed and sustained in all of our efforts by the progressive spirit of the press of New Orleans, and by the merchants, we put the new system into practical operation and threw open the Mississippi to commerce June 10, 1885. As it stands to-day, we sincerely believe in a nearly perfected state, it is the consummation of experimental effort, through a long and tedious process, beset with difficulties of the most perplexing and often disheartening kind. Without precedent, having to deal with natural

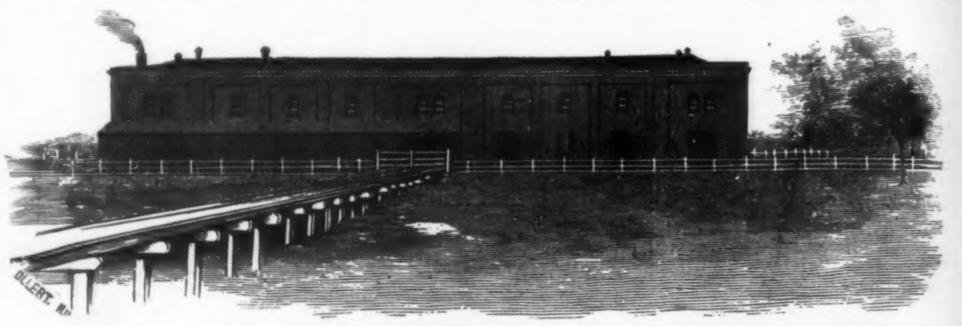


FIG. 5.—BRICK BUILDING IN WHICH IS LOCATED THE SUPERHEATING CHAMBER; GANGWAY IN FRONT CONNECTING WITH DISINFECTING WHARF.

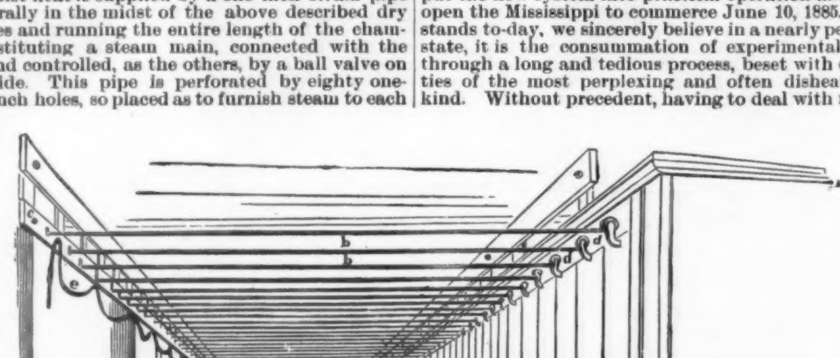


FIG. 6.—FRONT VIEW OF CLOSED SUPERHEATING CHAMBER (60 FEET LONG).

a, panels; *b*, rods upon which panels are suspended and travel; *c*, outer support of rods; *d*, rollers suspending panels on rods; *e*, fire hose.

forces of prodigious power, repeatedly encountering unexpected difficulties, meeting with accidents, obliged continually to devise improvements upon our several inventions, and continually combating a surly discontent, and sometimes violent opposition, from those subjected to the sanitary processes, while these were still in an imperfect and unsatisfactory stage of development, the modernizing of quarantine and bringing it into line with other branches of science and art in the general progress has been an expensive and difficult task.

We submit to your honorable committee the foregoing plans and specifications of the "System of Quarantine" established by the State of Louisiana in order to place the results of our experience in the hands of those who, like ourselves, are compelled to resist pestilential invasion by maritime quarantine. We do this encouraged by the hope that others may find in these results matter worthy of consideration and beneficial in strengthening their defenses against a common enemy.

The following are the requirements imposed upon all vessels arriving at the quarantine stations in the State of Louisiana during the quarantine period beginning about May 1 and ending Oct. 31:

All vessels arriving at the several quarantine stations in the State, together with their crews, passengers and their cargoes, shall be subjected to the inspection of the quarantine officers at the said stations. All vessels, together with their cargoes, crews, passengers and baggage, arriving at the Mississippi quarantine station from intertropical American and West Indian ports shall be subjected to thorough maritime sanitation, according to the following schedule: first class—vessels arriving from non-infected ports; second class—vessels arriving from suspected ports; third class—vessels arriving from ports known to be infected; fourth class—vessels which, without regard to port of departure, are infected, that is to say, vessels which have yellow fever, cholera or other contagious or infectious diseases on board at time of arrival, or have had same on voyage. Vessels of the first class to be subjected to necessary maritime sanitation at the upper quarantine station, without detention of either vessels or persons longer than may be necessary to place such vessels in perfect sanitary condition. Vessels of the second and third classes to undergo the same conditions together with detention for observation for a period of five full days from hour of arrival in quarantine. Vessels of the fourth class to be remanded to the lower quarantine station, there to undergo sanitation and detention of vessels and persons such length of time as the board of health may order.

The five days' detention, as above provided, shall apply to all ports of the Gulf of Mexico and the Caribbean Sea, exception being made in regard to vessels coming from ports south of the equator, whose period of detention shall be three days. All vessels arriving from Mediterranean or other ports known or suspected to be infected with cholera, or which may hereafter become infected, shall be subjected to maritime sanitation and such detention as the board of health may determine. Vessels arriving from the above named ports and places, and belonging to the second, third, or fourth class, as set forth in the foregoing schedule, shall not be allowed to pass the Rigolets or Atchafalaya quarantine stations or other state quarantine stations which may hereafter be established, without having undergone a period of detention of forty days, and thorough cleansing and disinfection.

SPECIAL SUGGESTIONS TO OWNERS, AGENTS, MASTERS OF VESSELS, AND PASSENGERS.

The Louisiana state board of health recommends the following suggestions to agents, owners, masters of vessels, and passengers for the purpose of facilitating the work of quarantine officers and reducing the period of detention to a minimum: 1. That vessels should be stripped during the quarantine season of all woolen hangings, carpets, curtains and such like materials, and upholstered furniture, as far as practicable, hair or moss mattresses to be replaced by wire or wicker beds. 2. That, as far as possible, vessels trading with tropical ports should be manned with acclimated crews. 3. Masters of vessels, ship and consular agents are earnestly requested to instruct passengers from quarantinable ports to dispense, as far as possible, with baggage which may be injured by wetting, in case of pestilential outbreak on board, while undergoing disinfection. Such passengers are especially warned against bringing silks, laces, velvets, and other fabrics of delicate texture, as they will be compelled to assume all risks of injury. 4. While in ports infected with yellow fever, vessels should be anchored out in the harbor when this is possible, and the crew prohibited from going ashore, especially at night. 5. When practicable, cargoes should be loaded in such a manner as to allow access to the pumps, and also to enable the quarantine officials to pump out and wash the bilge. 6. Special attention should be given to cleanliness of vessels and persons, and provision should be made for all possible ventilation of the entire vessel. The best disinfectants and instructions for using same can be obtained by application to the board of health or any of its officers. 7. Masters should, before arrival, see that the bilge is thoroughly pumped out and cleansed, and that the entire vessel be put in such good sanitary condition as to permit of the least possible detention. Fruit vessels particularly should be kept thoroughly cleansed for the purpose of avoiding delay at the quarantine station. 8. Vessels observing the above recommendations will receive special consideration at the quarantine station, detention and cost of cleaning, disinfecting, etc., being materially lessened thereby.—*The Sanitary News.*

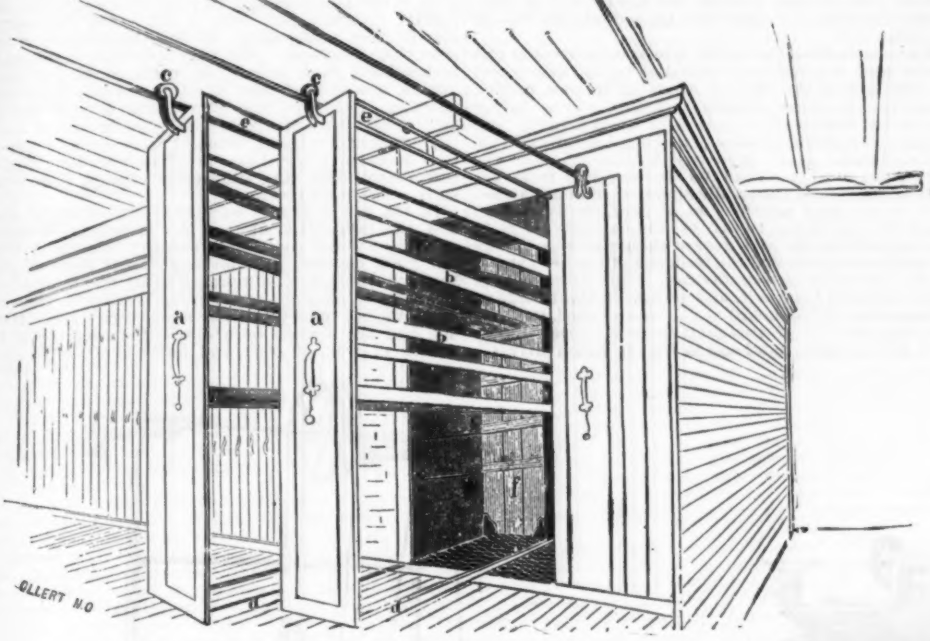


FIG. 7.—SUPERHEATING CHAMBER; TWO PANELS DRAWN OPEN.

a, panels. (Two lower rack bars not shown.) *b*, rack bars; *c*, rollers; *d*, iron bars connecting front and rear panels; *e*, rods upon which panels are suspended and travel; *f*, rear panel. Galvanized iron ½ inch mesh screen in bottom of chamber.

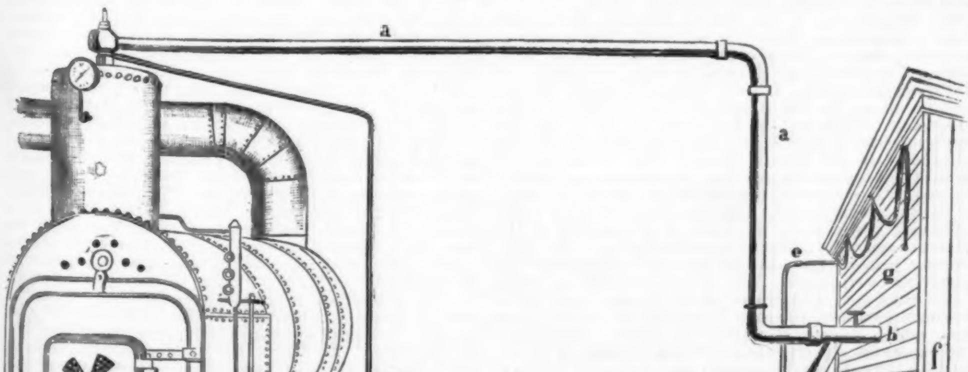


FIG. 8.—BOILER AND STEAM CONNECTION WITH SUPERHEATING CHAMBER.

a, steam main from boiler; *b*, pipe supplying dry heat; *c*, pipe supplying moist heat; *d*, bleeder; *e*, pipe from pump supplying fire hose; *f*, front of chamber; *g*, end view of chamber.

MR. CASE'S CARBON BATTERY.

WE learn with satisfaction that Mr. Willard E. Case is continuing his researches upon the reversible batteries of the type which (in the autumn of last year) he was the first to make known. A full account of Mr. Case's original heat cell may be found in the *Electrician* of Aug. 6, 1886. In this cell the elements consisted of carbon and tin, and chromous chloride was employed as the electrolyte. At a temperature of 60° F. the cell has no measurable E. M. F., but at 140° F. it attains an E. M. F. of a little over 0·2 volt. When exhausted it has only to be allowed to cool down in order to regain its original chemical constitution. No hydrogen is evolved during either charge or discharge, and therefore it is ideally possible that a cell of this type should last forever without renewal of material or any other attention besides the supply of energy in the form of heat.

In the form originally described by the inventor it was evident that for certain reasons, of which the smallness of the E. M. F. obtained is the most prominent, the results could not be expected to be of a highly economical, nor even, perhaps, of an entirely practicable character. But attention having once been awakened to the possibility of effecting a conversion of energy of this type, there could be little doubt that substantial improvements would be effected. It is only the more satisfactory that the improvements should be effected by the original discoverer of the method.

The discovery of the chemical reaction upon which Mr. Case's earlier cell is based was made, however, by M. Henri Loewel, and is described in the *Chemist*, vol. viii., page 476. A solution of chromous chloride added to stannous chloride precipitates tin, but when the solution is heated to about 140° F., the metal is redissolved, and the original salts are formed. Chromous chloride is, however, a difficult reagent to employ, as it readily absorbs oxygen from the air, forming the oxychloride, which is insoluble.

At present, we have only somewhat meager details of Mr. Case's new cell, but we understand that chromous chloride has been replaced by chromic chloride (probably for the above named reason), and that the tin is employed in the form of a liquid amalgam. The precipitated tin formerly rested at the bottom of the cell upon a horizontal plate of carbon. The addition of mercury is therefore probably chiefly with the view of making better contact.

The low E. M. F. must, however, still be an insurmountable obstacle to the practical success of the cell on any extensive scale, and it is evident that if the direct conversion of heat can be profitably effected in this manner, it must be by some different combination of elements. What is wanted, therefore, is a suitable chemical reaction reversible with change of temperature (such change not exceeding the limits of say 20° C. to 100° C.), and capable of yielding, with carbon as a negative electrode, an E. M. F. of respectable proportions. Such cells would form an ideal battery for household use, and would clear primary batteries altogether out of the field, or rather the house.—*The Electrician.*

MAGNETIZATION OF IRON.

A PAPER on the magnetization of iron in strong fields was read at the recent British Association meeting by Professor Ewing, F.R.S., and Mr. W. Low. Read by Professor Ewing: "In the experiments described iron was subjected to very intense magnetization by placing a narrow neck between two massive pole pieces. In this way values of magnetic induction higher than those previously reached had been attained. Through the kindness of Professor Tait the large electro-magnet of the Edinburgh University had been transferred to University College, Dundee, and by its means the induction was pushed up to the value of 38,000 C.G.S. units. There seemed, indeed, to be no limit to the value attainable, and so the neck was then turned down to about one-sixth of its previous diameter, and the induction was forced up to 45,000. By turning the neck still further, and annealing it, the highest value of 45,350 was reached. An attempt was made to determine the strength of the magnetic field in the immediate neighborhood of the neck. The quantity

$$\frac{B\text{—field}}{4\pi}$$

where B was the magnetic induction, was found to change from 1,680 in an experiment where B was 24,700 to 1,420 in the case of the highest value of B attained. This would favor the idea that the intensity of magnetization has a limit. But it is difficult to be quite sure that the field in the immediate neighborhood of the neck is the same as in the neck itself. In order to overcome this difficulty the field in the air round the neck was explored by means of three or four coils wound one on top of the other. This will show if the field is varying fast near the iron. If not, it would be natural to assume that the field is much the same as in the iron, because in the median plane there is no surface magnetism.

IMPROVED FRONT SLIDE LATHE.

WE had recently an opportunity of examining a front slide lathe, constructed by the London Lathe and Tool Company, London, a lathe which is somewhat unique in many points of detail. Fig. 1 is an illustration of the lathe as used for ordinary metal turning or screw cutting. Fig. 2 shows it with overhead attachment, and with drilling spindle set in the slide rest. The principal novelty is the front slide, which has long been advocated by some as preferable to the ordinary form of saddle placed upon the top of the lathe bed, on the ground that the wearing surfaces in the former, being vertical, are to some extent protected from the cutting action of the chips and grit which fall upon the top of the lathe bed, and insinuate themselves between the horizontal faces of the saddle and the bed surface. Also, the front slide can be readily moved along to the right, quite clear of the poppet, when the lathe has to be used for plain hand turning in wood or metal, and this is at least convenient in a lathe doing a mixed class of work. In spite of the necessary overhang of the front slide, to which exception has been taken on theoretical grounds, it is yet perfectly rigid, being in fact clamped firmly with set screws and upper and lower adjustment strips against the front of the bed, on bearing surfaces of good width. The hand traverse of the saddle is effected by means of the handle seen in front. This turns a spiral pinion, which again imparts motion to a similar spiral pinion of twice the size encircling the nut of the leading screw. The screw, of steel, has four threads per inch, and one turn of the handle therefore moves the saddle $\frac{1}{8}$ in. But there is also a division plate on the front of the saddle, by means of which the traverse can be determined to the $\frac{1}{768}$ of an inch. This capacity for minute adjustment renders the use of a compound slide rest unnecessary—the provision enabling the rest to be set for the cutting of any threads, however fine. The absence of a rack for quick return seems at first sight an objectionable feature, but this is partly compensated for by the rapidity with which the handle can be rotated; and further, since we are not concerned with a lathe having considerable length of bed, but with one of 4 ft. only, it is really not necessary to add to the work, and cost, by the introduction of a rack traverse.

The tool box shown in Fig. 1 is clamped in a socket bolted down on the top or surfacing slide, and the latter is actuated by means of its handle, also seen in front. Its surfacing screw has ten threads per inch, and its head is divided into tenths of an inch, so that a movement of $\frac{1}{100}$ of an inch of the tool can be determined. Both traversing and surfacing motions being thus capable of minute measurement, the rest possesses the advantages of a compound slide, without its multiplication of parts. The actual tool holder fits into a socket, which is bolted to the surfacing slide, and is clamped therein by means of a divided lug and pinching screw. The length of slide available for surfacing can be nearly doubled by moving the socket along from one end to the other, and reclamping it in the T slots. To this same socket is also fitted a drilling spindle, seen in Fig. 2, for ornamental work. When the entire saddle is moved to one side, the hand rest, seen on the end of the bed in Fig. 1, can occupy its place. Its tee is also clamped in a divided socket, thus avoiding bruising of the shank, and affording better security than the pinching screws ordinarily used with this form of rest. The lathe is thus adapted to the use of the ornamental turner—to metal turning, either with slide rest or hand tools, and to wood turning likewise.

The head stock is back-geared, but its construction is modified in such a way that the front toothed wheel, which is driven by theback gear, is utilized as a division plate.

The device is simply this: The common locking nut which in ordinary lathes passes through a slot in this front wheel to the cone pulley is dispensed with, leaving the face of the wheel quite plain and free for the holes drilled for the index peg. The clamping is effected at the back or small diameter of the cone, by means of a nut encircling the mandrel, and made to pinch against the cone with a "tommy," with sufficient force to cause the cone and cog wheel to revolve together. The circles of holes on the wheel face number 192, 180, 160, 120, and 100 respectively.

Another distinguishing feature of this lathe is an arrangement of mechanism through which the motion of the saddle can be instantly arrested at a given period, or the lathe used for plain turning without interfering with or altering any combination of change wheels which may happen to be on the head stock at the time. This neat disconnecting gear is seen at the left hand end of each of the engravings. It consists of a rod sliding in lugs on the front of the bed, which rod is embraced by the boss of a small fork. This fork actuates a sliding clutch, which, when in gear, establishes connection between the leading screw to the right and the change wheel train to the left. When the saddle is set in a position corresponding with the intended termination of the screw thread or the cut, as the case may be, the clutch is thrown in, the rod is slid along in its lugs until its end touches the saddle, and is then pinched by means of a set screw tapped into the boss of the fork.

When, therefore, the saddle afterward arrives at this precise spot, it will thrust the rod along and disconnect the clutch, with the effect of arresting its own motion instantly. The close attention which the iron turner has to give when cutting screws or when turning into shouldered portions of work is no longer necessary with this automatic gear. Moreover, by throwing out the clutch, the head stock can be disconnected from the leading screw, and the saddle operated by hand alone; or by introducing another set of gear, partly seen in Fig. 2, the saddle can be driven automatically for plain turning without the back gear or change wheels. There is a small cord pulley at the back end of the head stock, but not shown in the engravings. This drives a large pulley situated behind it, and actuates a shaft running underneath the tool board at the back of the lathe. At the opposite end of this shaft there is a speed pulley (seen at the right hand end in Fig. 2), which drives a similar but reversed pulley placed on the right hand end of the leading screw. This last pulley is not keyed on, but tightened with a conical fitting, which is slackened when the leading screw is driven direct.

The treadle gear is seen to be different from that usually employed. There is no crank, but a pair of eccentric sheaves connected together with a pitch chain. The advantage claimed for this arrangement is that a variable stroke is obtainable, according to the position given to the lower sheave relatively to the upper one. This last is fast upon its axle, but the lower one can be moved into any position, its spindle being loose in the treadle frame. The stroke can be varied from zero to the position of greatest eccentricity allowed by the sheaves, thus affording greater leverage for driving during heavy turning than for light work.

We may here refer to the mode of lubrication of the driving axle. This provision is not shown in the illustrations, because the addition has been made since the engravings were made. The axle is centered on pivots in the usual way, but waste of oil is prevented by inclosing the ends of the axle in encircling hollow brass caps, which pass partly over the pivots themselves. The oil cannot fly off while driving, because it is confined by the caps, and it cannot drip while the lathe is at rest, because it remains in the bottom hollow of the same. On the whole, the lathe we illustrate is well designed. The material and workmanship are, to all appearances, of the best, and the fact that it has been designed by and constructed under the supervision of Mr. Northcott will render it interesting to the readers of his well known book on "Lathes and Turning."—*Industries.*

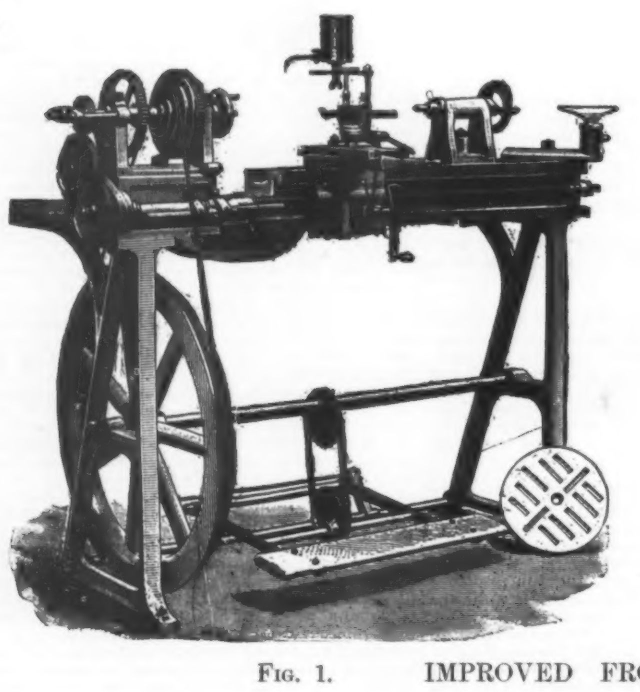


FIG. 1. IMPROVED FRONTSLIDE LATHE. FIG. 2

MIXTURE FOR CLEANING GREASE SPOTS.

EQUAL parts of stronger ammonia water, ether, and alcohol form a valuable cleaning compound. Pass a piece of blotting paper under the grease spot, moisten a sponge, first with water to render it "greedy," then with the mixture, and rub with it the spot. In a moment it is dissolved, saponified, and absorbed by the sponge and blotter.

GLASS MAKING.*

By C. HANFORD HENDERSON, Professor of Chemistry and Physics, Philadelphia Manual Training School.

PROFESSOR HENDERSON was introduced by Dr. Persifor Frazer, Professor of Chemistry in the Institute, and spoke as follows:

LADIES AND GENTLEMEN: It is related that, when the Queen of Sheba went to visit Solomon, that astute monarch so arranged his audience throne that the Queen and her suite in approaching would be obliged to pass over a floor of glass, under which was flowing water and fishes swimming. For the legend has it that the wisest of men was decidedly curious. Having heard that his queenly guest labored under the disadvantage of a deformed foot, his ingenuity suggested the device of the flowing water, thinking that the lady's anxiety for her draperies would discover to the king of the Israelites and his court whether rumor had rightly reported her. But I am much disposed to ascribe this performance to the imagination of one later than Solomon. Not only would so inhospitable an act have been notably at variance with the royal genius, but at that time it would scarcely have been possible. Not even the 120 talents of gold and the very great store of spices and precious stones which the admirer of wisdom brought with her as a present to Jerusalem could have purchased a plate of glass sufficiently large and sufficiently clear to have made such a deception possible.

In the production of curious works of art in glass, and the fabrication of rare bits of colored ware, the ancients showed themselves scarcely inferior to modern glass makers, but the magnificent sheet of glass through which we of a morning study the signs of the weather, or admire the tempting display in the shop windows, is a luxury peculiar to our own times. If our age had not already been devoted successively to the genius of iron, of steel, and latterly of electricity, I think we might designate it, not without reason, the "age of glass," so manifold have been the applications of this material.

That we must, however, ascribe to glass a great antiquity is beyond question. Some ingenious investigators have carried its origin back to the time of Tubal Cain, the patron of the metallurgist's art, but their following has been very small. The most commonly received story is that told by Pliny and Tacitus, which ascribes the origin of glass to an accidental discovery made by a company of Phenician merchants. These, it seems, had landed on the sandy coast of Palestine, and in heating their cooking vessels over the fire, made use of soda cakes taken from their cargo, no stones being available for the purpose. The sand and alkali being brought together in the fire, united to form a transparent fluid, and thus, say these historians, the first glass became known. But the formation of even a soda glass with no greater heat than that given by an exposed wood fire is open to chemical question. We have, however, much stronger testimony than this careless hearsay, which shows the fabrication of glass to have been an accomplished fact in the earliest historical times. To Egypt, the home of most of the arts and sciences, we must look for the earliest examples of the blower's skill. On several of the ancient tombs, scenes are depicted which represent unquestionably different stages in the manufacture of glass. But what is even more conclusive, interesting examples of this early art have also been discovered. A glass bead found at Thebes, and described by Sir Gardner Wilkinson in his *Manners and Customs of the Ancient Egyptians*, formed at one time a part of a royal necklace. It has engraved upon it the name of Queen Hatason, the wife of Thotmes III., who reigned 1500 B. C. The industry, thus early established, seems to have attained a national importance, for when the country was subdued by Cæsar Augustus, he decreed that a part of the annual tax should be paid in glass. The Romans were not slow in introducing so advantageous an art into Italy, and many interesting examples of their

* A lecture delivered before the Franklin Institute, January 10, 1887.

workmanship are now to be found in the museums of Europe. Venice, in particular, became celebrated for the delicate ingenuity of its glass workers. The ateliers of Murano preserved for many years the best secrets of the blower's art. The gradual spread of the industry throughout the world at large, and especially its development in the countries of Europe, forms a story of much interest, and one that I regret time will not permit me to repeat. But even confining our inquiry in time to the present, and in locality to America, there will be much that must of necessity be omitted. It is to be remarked, however, of these early manufacturers, that for many years glass seems to have been regarded as a material better suited to the requirements of the fine arts than to the demands of everyday life. Hence, it was to be found in the possession of few save the very wealthy. With this usage in view, the early glass makers gave more attention to brilliancy of luster and depth of coloring than to the more useful qualities of transparency and size. In this, it cannot be denied that they met with marked success. Some of the color effects in glass of the twelfth century cannot be imitated at the present day, and it is even whispered that not a few of the famous gems in the historic crowns of Europe owe their origin to the crucibles of these early chemists rather than to the laboratory of nature.

The term glass calls to our mind an amorphous solid, at once hard and brittle, and varying in its translucency to the most beautiful transparency on the one hand, and on the other to absolute opacity. It is a mixture of different silicates, compounds of silicic acid, with the bases soda, potash, lime, magnesia, alumina, iron, and lead. Every true glass contains at least two bases united with the silica, and generally, by virtue of the impurities associated with the crude materials, traces of several more. We have, therefore, grown into the habit of designating the different kinds of glass by the names of the two principal bases. Thus, we speak of window glass as a lime-soda glass; of flint glass, used for optical instruments, as a lead-potassium glass; of the well known Bohemian product, as a potash-lime glass, and so on through the list. It is a valuable property of these mixed silicates that they have a fusibility much below the mean of the constituent salts. Thus, while the silicates of alumina, lime, and magnesia are almost infusible alone, they become quite manageable when associated with the silicates of soda and potash.

The operation of glass making is one which involves not only considerable skill in the chemic art, but also not a little familiarity with the principles of physics. I scarcely know which to admire the more—the nicety with which the glass maker regulates the proportions of his charge, so as to produce this beautifully clear substance, or the dexterity with which he handles the finished product, and adapts it to our uses. The several steps in the process of glass making depend from the very beginning—the choice of the raw materials—upon the purposes to which the glass is to be put. While there is great similarity in the operations of melting, blowing, moulding, and annealing, the differences in the several manipulations are sufficiently marked to make it desirable that each special branch of glass manufacture shall be described separately. The processes of fabrication can better be classified by referring them to the character of the product than to the constitution of the glass. Following this principle, we will find that all the more common varieties of manufactured glass will be included in the following table:

MANUFACTURED GLASS.

- Flat ware.
  - Blown.
    - Sheet glass.
    - Crown glass.
  - Cast.
    - Plate glass.
    - Mosaic glass.
    - Optical glass.
  - Pressed.
    - Decorative Pieces.
- Hollow ware.
  - Blown glass.
  - Pressed glass.

I shall consider flat ware first, as being far the more important of the two main classes. I think you will agree with me that, however convenient and helpful glass may be when applied to the construction of domestic or scientific utensils, its use for these purposes sinks into utter insignificance when compared to its much larger value in filling the windows of our houses, in lengthening our days to the dimensions assigned by nature, and in permitting us to enjoy the sunshine of outdoor life at all seasons of the year without being exposed to the inclemencies of the weather; or its more subtile use in optical instruments, in giving sight to the almost blind, in endowing the infinitesimal world, through the aid of the microscope, with sensible proportions; or by means of the telescope, bringing the infinite regions of space within the scope of human observation. When these uses of the material come up before the mind, glass becomes not only an object of interest from the skill required in its fabrication, but also an object of reverent wonder from the larger universe it has made possible to us.

Among the many industries that have been benefited by the utilization of natural gas, there is probably none in which the results have been so marked as in the manufacture of window glass. For a number of years past, American sheet glass has been undoubtedly inferior to the product of European factories, and has consequently occupied but a secondary position in the estimation of our builders and architects. The foreign makers, and more particularly those of France and Belgium, have hitherto shown a superior skill in the management of their materials. They seem to have held the secret of obviating the bad effects of impurities in their fuel. This result has been made possible from their greater experience in the industry and from a better construction of furnaces. In the more perfect plants, crude fuel has been abandoned, and manufactured gas used in its place, thus anticipating the advantages of natural gas, with the important exception, however, of its cheapness and almost total freedom from sulphur. The more favorable conditions prevalent abroad made imported glass synonymous with best quality. That the circumstances of the industry have now so far changed that American glass makers can successfully compete with foreign producers of the best reputation, and can even claim certain points of superiority for the home product, is a subject for hearty congratulation. The well known ingenuity of American inventors has, in a measure, effected this improvement, but perhaps the substitution of gaseous fuel has been the most potent cause of our recent successes. The metamorphosis of the crude material into a clear and brilliant pane of glass involves about the same operations in all our modern factories, but in each establishment the details of manufacture are slightly varied. I shall therefore call your attention to-night to the fabrication of sheet glass as carried out at Pittsburg, for in that city one can see the best American practice.

The manufacture of window glass depends for its success upon the closest attention to details, and its history is therefore one of delicate manipulations. It is a very easy matter simply to make glass. Sand, alkaline bases and heat are the only elements needed to accomplish the transformation. The iron master frees his ores from their associated gangue by making it into a fusible silicate of lime and alumina, an opaque glass. The assayer separates his metal from its impurities by adding suitable fluxes until all earthy matters are gathered into a fusible slag, and float above the metallic button as a molten glass. And even nature, when her local caldrons bubble over in the volcanoes, shows that she too is a giant glass maker. But to make good glass; glass that shall be clear, transparent, colorless; that shall simulate the purest water of the mountain stream—this requires skill and patience, and not in one part of the process alone, but in all, from the mixing of the crude materials to the annealing of the finished product, the glass maker must be alert and intelligent.

Window glass, as we have seen, is a lime-soda glass, or a mixture of the silicates of lime and soda. It approaches quite nearly to the composition represented by the chemical formula $CaO,Na_2O,6\ SiO_2$. To supply the ingredients required by this formula, the raw material, or "batch," employed consists of about thirty parts of lime, forty of alkali, and a small but varying amount of pulverized charcoal to each 100 parts of sand, the commercial representative of silica. These are thoroughly ground and mixed together before being introduced into the furnace. Some manufacturers make their alkali all sulphate of soda, while others employ a mixture of sulphate and carbonate in the proportions shown by their experience to give the best results. Not only does the composition of the alkali vary greatly, but the relative amounts of the three components of the batch are different in every establishment, and even in the same establishment vary in accordance with the quality of the crude materials.

Where gas is used, the construction of the melting furnace is very simple. A plain rectangular floor or hearth gives support to eight or ten glass pots, standing two abreast; a series of round openings on each side of the furnace permits free access to each pot; the gas is admitted at each end and is mixed with air which has previously been heated by passing through chambers in the fire brick arch. An intense heat is thus obtainable, and one that has the advantage of being under the most complete control. A well is built under the furnace in order to collect the molten glass should a pot break, and so avoid loss of material or stoppage of the work. An arch is provided at each end of the furnace to permit the admission or removal of the pots. When the furnace is in blast, the opening is closed by fire bricks and luted with clay.

The manufacture of crucible pots is the most tedious and exacting process connected with glass making. It requires constant care, for if the treatment be any way imperfect, the entire subsequent work of the crucible will be unsatisfactory. At Pittsburg, the pots are generally made up of a mixture of two parts raw fire clay, two parts burned fire clay, and one part ground pot shells. The well ground mixture is placed in lead lined bins or troughs, and sufficient water added to make the mass plastic. It is turned once a day for a period of about four weeks. The workman kneads the mass with his bare feet in order to make it tough and free from air.

In this country the pots are generally formed by hand, the temperature and humidity of the work room being kept as nearly constant as possible. The bottom of the pot is first formed, and then the sides built up gradually from day to day, the entire process occupying about six weeks. The uncompleted walls are always left covered with damp cloths in order to prevent premature hardening. The pots are ordinarily made 33½ inches deep, and 42½ inches across the top. The thickness varies from 3½ inches at the base to 3 inches on top, while the bottom is 4 inches. Their capacity is from fourteen to sixteen hundred pounds of molten glass. When the pots have been completed, they are permitted to stand in the work room for several months in order to dry very gradually. They are then placed in small heating furnaces, where the temperature is slowly raised to that of the melting furnace. The transfer from one to the other is made as quickly as possible. The interior of the crucible is then glazed with molten glass, and is ready to receive the raw materials.

One third of the charge is first placed in the pots, and allowed to melt before the addition of the rest of the batch. If the furnace is in good condition, the melting proceeds from below upward, the cone of raw material gradually sinking into the bath of molten glass. If this does not occur, if the fusion begins on top, it is a very plain indication that the heat has not been properly regulated, and that a long period will be required to accomplish the complete melting of the charge. At the end of about four hours another third is added, and after a similar interval of time, the remainder of the batch is finally introduced. About two pounds of arsenious acid are put in with the last charge, in order to bleach the glass by converting the iron present into a higher oxide. At some establishments, the peroxide of manganese is used to accomplish the same purpose, but it has the disadvantages of giving the glass a pinkish color if used even in slight excess. It is also believed to make the transparency of the glass less durable.

Some years ago, an excess of manganese was employed intentionally, in the manufacture of window glass, as it was thought that a pretty face looked prettier when seen through rose colored glass. Some of you doubtless remember having seen this decidedly pink glass in not a few of the older houses of the city. It may indeed be seen at the present time even, for its use was revived by the severe hail storm of seventeen or eighteen years ago, when the neglected manganese glass was again brought into requisition by the emergency.

After the contents of the pot have become quite liquid, a capping of broken glass is added to fill them up completely. The entire melting of such a charge occupies about sixteen hours. During the latter portion of this period, the heat is somewhat reduced to make the glass less liquid, and prepare it for gathering. But first, the surface of the molten "metal" must be freed from all impurities by skimming. A fire clay ring, which was introduced into the pot when it was first put in the furnace, floats upon the bath, and the gatherer, by removing all the scum from the interior of this ring, always has a clear surface from which to draw.

The glass is gathered on the end of a wrought iron blowpipe, about five feet long, the end of which is decidedly flared. The first dip brings out but a small lump of glass, which is gotten into symmetrical oval shape by a careful turning of the pipe. Three times the process is repeated, until the gatherer has a mass of from fifteen to twenty pounds of glass on the end of his pipe. When window glass of double thickness is to be made, the metal must be gathered as many as four or five times. The resultant ball in this case weighs from thirty to forty pounds. It is at the final dip that the gatherer's greatest skill is called into requisition. To get the mass of red hot plastic glass into symmetrical shape, and satisfy himself that it is thoroughly homogeneous throughout, he rests his pipe on a convenient fulcrum, and by a rapid revolution, while the end carrying the glass is still in the furnace, causes the last glass added to completely overlap the former ball. The entire mass is brought almost to the liquid condition, and by a skillful manipulation of the blowpipe the fold of glass is turned into a spiral and worked to the end of the mass. The red hot ball of glass is now taken to a wooden mould, and by a few dexterous turns is formed into a pear-shaped ball. The mould is kept from burning by being constantly moistened with water, which, in contact with the heated glass, assumes a spheroidal condition, and looks like so many globules of mercury. When this has been accomplished, the gatherer's duty is at an end, and he hands pipe and glass over to the blower.

In France and Belgium, the same furnace is generally used for both melting and blowing, but in England and this country it is found not only more convenient, but even more economical, to use separate furnaces. The blowing furnace adapted for gaseous fuel is similar in many respects to that used for melting. It is constructed with a series of side openings, somewhat larger in diameter than those of the former, and simply provides an intensely hot chamber for controlling the temperature of the glass while being blown. The gas, however, instead of being introduced at each end, is burned directly under the openings, or blow holes. The requisite amount of air is mixed with the gas by means of fire clay chimneys surrounding the burners in a manner precisely similar to the chimney in the Bunsen burner. In order to prevent the flame from impinging directly upon the glass being manipulated, fire clay slabs or bricks are placed a short distance above each burner, and thus divide the flame into harmless jets.

In the most completely equipped works, the division of labor is carried into thorough practice. Each man knows how to do one particular thing, and does it. The blower, for instance, into whose hands the red hot ball of glass has just been consigned, knows nothing of crude materials, melting processes, or molten baths. Nor, on the other hand, is he supposed to have more than a vague conception of what is meant by a pane of glass. His crude material is the pear-shaped mass on the end of the blowpipe; his finished product, a large cylinder of glass. The skill with which he effects his part of the many transformations required in the genesis of a window pane is, however, the most attractive in a process nowhere devoid of interest. His first act is to grasp the pipe, and with the ball of glass still resting in the mould, blow through the mouthpiece until a large bubble of air is formed in the mass. Then, with alternate blowing and manipulating, he increases the bubble, until the mass assumes a shape not unlike that of the large carboys used in the transportation of acids. On each side of the furnace, and directly in front of the openings or blow holes, there is a wide platform, the long openings in which, running at right angles to the furnace, permit the blower to swing his pipe and ball of glass in a pit beneath. Blowing, swinging and heating, he extends the bubble, until in place of the ungainly carboy, with its disproportionately thick bottom, he has a beautifully symmetrical figure, the shape of an enormous test tube. From time to time, however, during these operations, it happens that the glass flows a little too freely, and that there is danger of the sides of the cylinder becoming too thin. To avoid this result, the blower throws his cylinder into the air whenever he finds that the glass is too liquid, and so permits it to settle back upon itself. The tube being by this time about five feet long, and the blowpipe as many more, one can readily fancy that this apparently playful toss requires both skill and muscle. In the case of the larger cylinders, such as will furnish a pane 66×54 inches, and which must be made of double thickness, the labor is so great that few men are found who are capable of its performance.

When the tube has been formed to the satisfaction of the blower, he allows it to become comparatively cool. He then thrusts the end into the furnace, blows into his pipe, and quickly covers the mouthpiece with his hand. A slight report is soon heard. The end has become softened with the heat, and the confined air, expanding with the increasing temperature, has blown a hole in the glass. Resting his pipe on a suitable support, and still keeping the glass in the furnace, the blower gradually turns it around. Under the influence of this centrifugal force, the hole grows larger and larger, until he no longer has a test tube at all, but in its place an open cylinder. This is quickly withdrawn from the furnace, and permitted to depend into the pit below, until the plastic edge passes to a cherry heat, and the cylinder can be taken away without danger of getting out of shape.

The blower's part is now completed, and after a moment's rest, he has another pipe in his hand, and is repeating his heavy labor.

The neck of the cylinder and its attached blowpipe are separated from the cylinder proper by wrapping

around the end of it a thread of red-hot glass, and after its removal applying a piece of cold iron to any point heated by contact with the thread of glass. A red-hot iron is also passed along the interior surface from end to end, making a longitudinal crack; or the same result may be effected by means of a diamond attached to a long handle. We have now a perfect cylinder, open at both ends, and having a crack its entire length. Another step in its transformation into a window pane has been accomplished.

The cylinder is now taken to a separate building to what is known as the laying-in furnace. The hearth is made circular, and is divided into a number of sectors, separated from each other by fire clay bridges. As the hearth revolves, the different sectors move through as many separate compartments of the furnace, the temperature of which may be varied at pleasure. The first compartment, which is only moderately warm, is known as the laying-in oven, and permits the cylinder to become gradually heated. A partial revolution of the hearth then carries it to the next compartment, the laying-out oven, where the temperature is sufficiently elevated to make the glass plastic. A large flat stone, manufactured out of fire-clay, prepared with the greatest care, occupies the floor of each hearth sector, and is adapted to receive the cylinder. In the laying-out oven, the crack is brought uppermost, and under the influence of the heat the cylinder gradually unfolds until it lies open on the stone like a sheet of rumpled paper. In the next compartment, the flattening oven, a workman irons out the plastic sheet with a moistened block of wood on the end of a long rod until it is perfectly smooth and flat. The smoothed sheet, by another revolution of the hearth, is taken to the compartment known as the dumb oven, where it slowly cools. A final revolution of the hearth brings it to the entrance of the annealing leer, next door to the laying-in oven, thus making the circuit complete. The process, you see, is quite continuous, and by a few simple operations transforms the cylinder into a flat sheet of glass. But still it is not ready for use. Were the glass taken from the dumb oven and permitted to cool in the air, it would be so brittle that it would be almost without value. It must therefore go through the process of annealing, or gradual cooling, before it can become serviceable.

The most improved annealing oven is that known as the "rod leer," which has come into general use in Pittsburg, and other localities where the best practice is followed. When the glass reaches this stage of its journey, it is picked up with a large two-pronged fork, and is placed upon a series of rods projecting from the mouth of the leer. These are found an immense improvement over the cars formerly used for the purpose. They handle each sheet separately, and are so arranged that when it is desired to make room for a fresh sheet, a part of the rods may be raised and carry the contents of the entire leer toward the cooler end, where all the sheets are eventually discharged. The glass remains in the leer from thirty to forty minutes, in place of several hours or days, as in the old-fashioned annealing ovens. When the glass is discharged, it is nearly or quite cold, and may be at once cut into proper sizes and stored in suitable frames.

This, with the exception of the important commercial transaction of converting the glass into money, completes the process in window-glass manufacture. In all departments of the work, the advantages derived from the use of gaseous fuel are becoming each day more evident. If you will examine, even casually, the differences between gas-made glass and the older article made with coal, you cannot help being struck with the manifest superiority of the new product. The surface of the glass, just as it comes from the furnace, is remarkably brilliant, and quite as beautifully clear as if it had been washed with hot water by some careful housekeeper, and dried with linen. A better and more thorough fusion is obtained from the more intense heat of the gaseous fuel, and, what is even more important, the contamination of the "metal" by particles of coal and cinder is entirely avoided. In the latter part of the process, in flattening out the glass cylinders, the advantages of gas are particularly manifest. When coal was used, the sheets of glass came from the laying-out oven covered with smoke, and infinitely worse than that, a white deposit of sulphur. It must be remembered that these impurities were gathered while the glass was in a semi-plastic condition, and that in consequence no subsequent washing or acid bath could entirely restore its brilliancy. The contrast between the two fuels, gaseous and solid, is perhaps still better shown by a glance at the history of those establishments which are not so fortunate as to possess it. Quite a number of large glass works throughout the West have admitted that the competition with the factories supplied with natural gas is too unequal, and have either suspended operations or have transferred themselves to the shadow of the nearest gas derrick. Several such migrations have been reported during the past year, and where this has not been possible, manufactured gas has in a number of cases taken the place of the crude fuel.

The manufacture of crown glass, though commercially much less important than that of sheet glass, possesses considerable historical interest, and within the past year or two has been brought into some prominence again from the use of the material in decorative windows. It possesses a brilliancy far superior to that of its younger rival, but the small size and unequal thickness of the panes obtainable do not permit it to successfully compete with the generous dimensions and constant uniformity of the sheet glass. The glass itself is alike in both, the differences between the two being due entirely to the subsequent manipulations, after the melting process has been completed. As before, the glass by several successive gatherings is collected on the end of the blowpipe, and by rolling on a table of metal or stone, known as the marver, is gotten into the shape of a cone, the apex of which forms the so-called "bullion point." The workman now blows into his pipe, expanding the glass into a small globe. This is subsequently enlarged, care being taken to keep the bullion point in the line of the blowpipe. The globe is then flattened to something of the shape of an enormous decanter, the bottom being very flat, and having the bullion point in its center. The pipe and its burden are now permitted to rest horizontally upon two iron supports. In the meantime, another workman has gathered a small lump of glass upon the end of his iron rod or "pouty," and by pressing it against an iron point, has impressed upon it the shape of a small cup. This is fitted over the bullion point of the glass, and soon becomes firmly attached to it. The blowpipe is separated from the glass by means of cold iron and a sharp blow. The open neck thus exposed is known in the glass worker's parlance as the "nose," and gives its name to the furnace where it is subsequently reheated. During this operation, the pouty is constantly and rapidly revolved. Under the combined action of heat and centrifugal force the nose gradually expands, the opening growing larger and larger until the piece has the shape of a typical crown. But this appearance remains only an instant, and in its place is seen a brilliant circular plate of glass, whose shape is only maintained by continuing the rotation of the pouty until the plate, or table as it is now called, can be laid upon a flat support. The pouty is then detached from the bull's eye by means of shears. As soon as they are sufficiently cool to be rigid, the tables are stacked in annealing ovens, where they remain from one to two days. Their diameters vary from a few inches to six feet, but the latter dimension is extreme. After annealing, they are divided by a diamond into two unequal parts, the larger of which contains the bull's eye. It can readily be imagined that a semicircle of glass, which has even the extreme radius of three feet, cannot be cut into square panes very advantageously, and this consideration, together with the small sizes necessary in crown glass, have more than counterbalanced its admirable brilliancy.

At the present time, crown glass, in the circular form, just as it comes from the annealing oven, is being used in decorative windows with very excellent effect. The glass is frequently tinted, amber being a special favorite, or else it is white, with the bull's eye colored. A very effective window of this sort may be seen in the hallway of the Tiffany Glass Works, in New York. It consists simply of a succession of crown glass tables, perhaps eight to ten inches in diameter, having opalescent and tinted bull's eyes. The use of the bull's eye alone is also becoming quite popular in mosaic window glass.

Sheet and crown glass are the chief representatives of the blown ware in the flat. I have described their manufacture in some detail, from the feeling that the former, at least, is the most important of all the products of the glass maker's art. In the next division of our subject we shall be brought to a consideration of a class of products, those obtained from casting, which are far more beautiful and wonderful than the former, which, since they affect the welfare of a smaller proportion of the civilized world, must be ranked economically of less importance.

(*To be continued.*)

[Continued from SUPPLEMENT, No. 630, page 10066.]

THE DEVELOPMENT OF THE MERCURIAL AIR PUMP.*

By Professor SILVANUS P. THOMPSON, D.Sc., B.A.

CLASS IIa.—SHORTENED DOWNWARD-DRIVING PUMPS.

STEARN† in 1877, working in conjunction with Swan at the problem of perfecting the incandescent lamp, devised a shortened Sprengel pump. It is obvious that the column of mercury in the Sprengel fall tube stands, during the later stages of exhaustion, at about seventy-six centimeters height, simply because the difference of pressure between the space inside the tube and outside it is about equal to one atmosphere. By removing a portion of the external pressure, the fall tube may be shortened to any desired extent. Accordingly Stearn applied an auxiliary pump, not at the top, as Sprengel had done, to accelerate the early stages of exhaustion, but at the bottom; the collecting chamber, K, being for this purpose closed, and put into communication with the auxiliary pump. Stearn's pump has undergone various modifications. In a recent form‡ there are three fall tubes of only about ten inches length, completely inclosed in a partially exhausted chamber. In this pump there are also means provided for carrying up the mercury from the collecting vessel back to an upper supply vessel by closing certain taps and opening others which admit the atmospheric air. By this means an extremely small quantity of mercury is made to do duty again and again, and the exhaustion is rapid, because with such short fall tubes there is less liability of the air bubbles to stick in the fall tubes. The action of the pump is made automatic by giving a periodic motion to a three-way cock, which puts a lower receiving chamber alternately in connection with the atmosphere and with the partial vacuum of the auxiliary pump. Stearn has embodied sundry other modifications in patent specifications.§

A compact modification of Stearn's pump has been devised by Mr. Swinburne,‖ who also has tried an inverted Sprengel pump.

The most recent shortened Sprengel pump is that of Dr. W. W. J. Nicol, described before the British Association, at Manchester, in 1887. Its arrangements are depicted in Fig. 26. The principle of its automatic action is identical with that of Von Babo, an auxiliary water-dropping air aspirator (not shown in the figure) being employed to draw in air at the aperture, A, regulated by a tap. This air draws up the fallen mercury in drops through the return tube, Z, on the left, and returns it into the supply chamber, S, at the top, whence it passes downward through a rubber tube, squeezed between the jaws of a regulating pinch cock, X, and rises through an air trap, *t*, into the pump head. The distributor is simply a horizontal glass tube, sealed into the pump head, and pierced with small holes above the openings of each fall tube. (This form of distributor originated independently with Mr. J. T. Bottomley and with Mr. Proctor.) The fall tubes, F F F, are connected to the pump head in the following manner: Below the pump head are sealed, on short pieces of glass, tubing of at least five millimeters bore. These are provided with small flanges, and drawn out conical below, so that they can be pushed very tightly through small India rubber plugs, *p p p*, which are firmly fixed in mercury cups. These mercury cups, which are strangulated, so as to nip the rubber plugs, are sealed to the fall tubes. The lower ends of the fall tubes pass into the collecting vessel, K, through simple packings, *s s s*, of rubber tube. The arrows show the course of the mercury. The tube, *d*, leads to the drying apparatus, and to the vessel to be exhausted. This pump can, of course, be used for exhausting only, not for collecting the gas for analysis. The entire height of the apparatus is less than one meter. A very small quantity of mercury—only three hundred cubic centimeters—is required. The entrance of water vapor at S or *a* is prevented by the use of tubes containing calcium chloride. These pumps are now manufactured for sale by F. Muller, successor to Dr. Geissler, of Bonn.

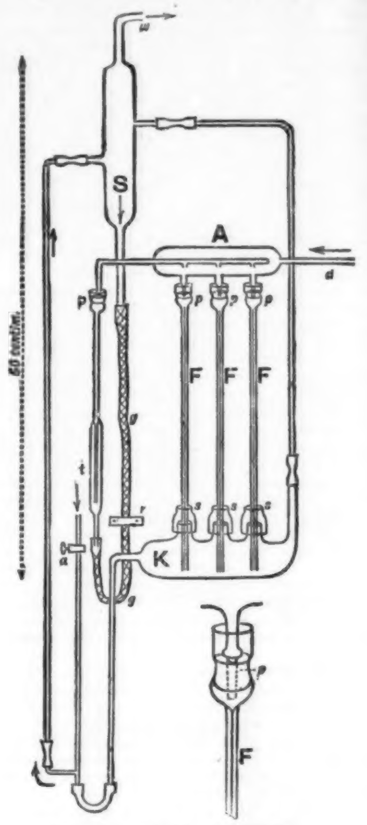


FIG. 26.—NICOL'S PUMP.

CLASS III.—UPWARD AND DOWNWARD DRIVING PUMPS.

The earliest example of a pump which drives the air up one barometric column and down another is the remarkable pump devised by Professor J. Mile,* of Warsaw, in 1828. This pump is described by its inventor as a hydrostatic air pump without cylinders, taps, lids, or stoppers. The description, as will be seen by Fig. 27, is literally true. The mercury is raised in the barometric tube, B, and pump head, A, by lifting an external cistern, S, of mercury by means of a winch, W. The rising of the mercury first cuts off communication with the vessel to be exhausted by entering the mouth

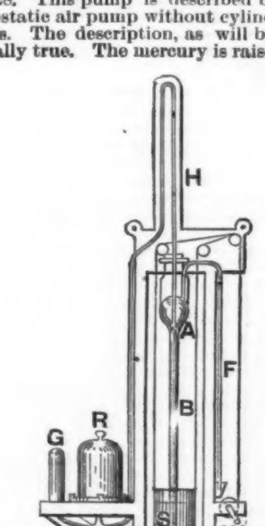


FIG. 27.—MILE'S PUMP.

* Lecture before the Society of Arts, London, November, 1887. From the *Journal* of the Society.

† Stearn and Swan. "On a New Form of Sprengel's Air Pump." Rep. British Association, 1877, p. 43.

‡ See Gordon's "Practical Treatise on Electric Lighting," 1884, p. 65, giving an excellent picture.

§ Stearn. Specification of Patent 5,000 of 1881. See also Dredge's "Electric Illumination," II., p. ccclxiv. Stearn's shortened Sprengel pumps have been now for several years furnished to the public by Messrs. Mawson & Swan, of Newcastle-on-Tyne.

‖ Swinburne, *Electrician*, xix., 72, 1887

* Mile. Neue hydrostatische Luftpumpe ohne Kolben, Haehne, Kappen, und Stopsel. "Dingler's Polytechnisches Journal," xxx., 1, 1828.

of the exhaust tube, which is sealed in through the pump head, and on further rising it expels the inclosed air through a narrow tube, F, sealed in at the top, which bends over to the right and terminates below in a cup of mercury, into which its open end dips. This exit tube and cup constitute a barometric trap, for when the supply cistern is lowered the air cannot return, the mercury rising in the tube, F, to a height depending upon the degree of internal rarefaction. To prevent the mercury from being forced into the vessel that is to be exhausted, the exhaust tube is prolonged overhead to a height exceeding that of a barometric column. The total height of this pump is, therefore, necessarily about nine feet. It may be looked upon as a sort of Swedenborg pump, the two valves that open inwardly and outwardly into the pump head being replaced by barometric air traps. With such a pump, properly used, a fairly high degree of exhaustion ought to be possible. Strange to say, this pump appears to have fallen into utter oblivion, and its useful features have been several times reinvented.*

The use of a second barometric column, down which the air is expelled from the pump head, is generally attributed to Professor Toepler † of Dresden, whose form of pump is shown in Fig. 28. Save in the use of a flexible

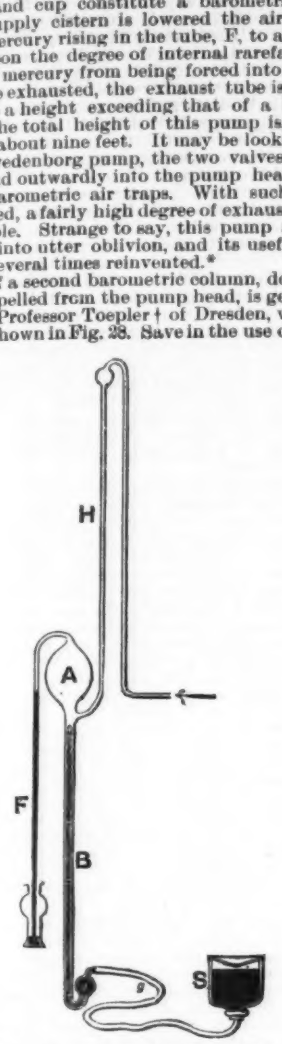


FIG. 28.—TOEPLER'S PUMP.

rubber tube, and in the manner of bringing the exhaust tube to the lower side of the pump head, this is identical with Mile's pump. A pump of similar form is sometimes attributed to Mendelejeff, but the writer has been unable to verify the reference. This pump has many of the advantages and disadvantages of the Geissler form of pump. It requires either the tall overhead tube or else an automatic valve. The exit tube, F, is more liable to fracture than any part of the Geissler pump. But, as there are no taps to get out of order, a higher degree of exhaustion can be attained than with any three-way tap arrangement opening into the outer air. There is no need even for any other gauge than the pump itself, for, as Toepler ‡ has shown, the degree of exhaustion can be measured (as in the McLeod gauge) by raising the mercury in the pump head to a marked point on the narrow tube just above the pump head, so as to compress the residual air into the top of the narrow exit tube, and then reading off the volume and the pressure of the same, and making the required calculations. It possesses this obvious advantage, that the last residua of air in the pump head are swept down the tube, F, by the mercury that falls over the bend—"Sprengelized" over, one might almost say. In fact, if it were not the case that this pump antedates Sprengel's, one would be disposed to regard it as a combination of the Geissler and Sprengel pumps.

The Toepler form of pump has received in recent years various modifications. E. Wiedemann § altered the overhead tube, H, by joining it at its base with two of Gimingham's air tight joints, allowing it to be removed to be cleaned. Neesen ‖ added the side tube shown at N in Figs. 18 and 33, to prevent the top of the pump head being broken off by violent uprushes of mercury in the large bulb. Guglielmo ¶ ingeniously connected the closed top of the collecting vessel (into which the exit tube discharged air and mercury) with the closed top of the supply vessel, so that as the latter was raised, and the mercury ran out of it, the air pressure upon the lower end of the barometric column in F was automatically lessened. Improved forms of overhead tube were suggested by Von Helmholtz** and by Schuller,†† and a very similar device was used by the writer in 1882 to connect a glow lamp to the Lane-Fox pump by merely sealing it to the top of a long barometric tube, which slipped on over the top of the open overhead tube—or of a tube connected with it—and dipped into an external ring of mercury in a cup forming a barometric air tight trap. Neesen ‡‡ designed a double acting pump on this plan, with two pump heads and two fall tubes, the mercury being mechanically driven alternately from one pump to the other by a piston working in a cylinder. The model has not yet been actually constructed.

* See, for example, H. Sutton, in *English Mechanic*, xxxi., 1882, as well as Toepler and Mendelejeff.

† Toepler. Ueber eine einfache Barometer-Luftpumpe ohne Hahne, Ventile, und Schadlichen Raum. "Dingler's Polytechnisches Journal," clxiii., p. 426, 1862.

‡ Toepler. "Sitzungsber. d. Naturwiss. Gesellsch. Isis in Dresden," 1877, p. 135. See also Bessel-Hagen, "Wied. Ann.," xii., 434, 1881.

§ Wiedemann. "Wied. Ann.," x., 206, 1880.

‖ Neesen. See below.

¶ Guglielmo. "Wied. Beibl.," v., 16, 1881.

** Von Helmholtz. See Bessel-Hagen, "Wied. Ann.," xii., 429, 1881.

†† Schuller. "Wied. Ann.," xiii., 533, 1881.

‡‡ Neesen. "Wied. Ann.," xi., 522, 1880.

Other improvements have been made in detail by Couttolene,* who drives the air into a partially exhausted space, by Diakonoff,† by Bessel-Hagen,‡ and by Karavodine.§ The latter interposes between the top of the pump head and the exit tube, F, a small chamber closed at the bottom by a valve consisting only of mercury standing over a capillary orifice, exactly resembling that previously described by Schuller (Fig 20). This has the result of causing the last portions of residual air to be expelled into a space containing a moderately perfect vacuum. This is a decided improvement. For, as was pointed out with respect to the Sprengel pump, the air carried down the narrow fall tube is necessarily compressed in order to drive it down against atmospheric pressure, and bubbles or films remain adherent to the glass.

In some modern modifications this is, to a very large extent, obviated by the device of so bending the eject tube or fall tube that the air expelled from the pump head need only descend a very few centimeters down the tube before it enters a chamber that is partially exhausted. In short, if by any device—whether by placing it at the top of a fall tube or by applying a good mechanical pump—a moderately good exhaustion can be maintained with a chamber such as that marked M, and this chamber is joined to the pump head by a descending fall tube, the length of this fall tube need not exceed the height of a column of mercury representing the difference of pressures between the two chambers. In the diagrams that follow, such a shortened fall tube is marked Q. It may be regarded as a sort of siphon air trap. Such an arrangement has been independently devised by several persons. It was patented by Siemens and Halske ‖ in Germany in 1884. Fig. 29 shows the device as originally designed. The

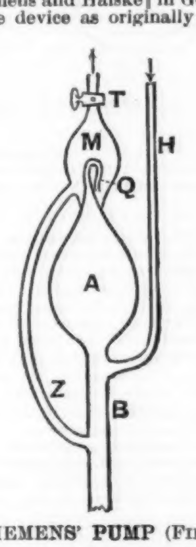


FIG. 29.—SIEMENS' PUMP (FIRST FORM).

pump head terminates in a capillary tube, which turns over into a pool of mercury in the base of the upper chamber, M, into which the residual air is driven with a very slight compression. When a certain amount has thus been collected, it is expelled by further raising the mercury and opening the top tap, T, which is otherwise kept closed. A wider tube, Z, which should be usually closed by a tap, serves to return to the pump shaft the mercury which may have been driven over into M. A later form of this pump, depicted in Fig. 30,

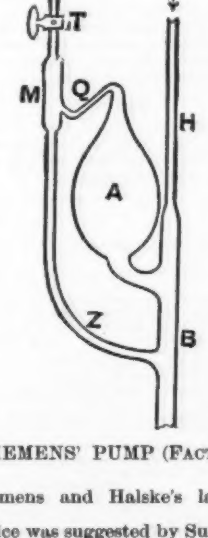


FIG. 30.—SIEMENS' PUMP (FACTORY FORM).

is used in Siemens and Halske's lamp factory in Berlin.

A similar device was suggested by Sundell,¶ who has further improved the arrangements at the bottom of fall tube so as to allow of other gases being admitted to the pump. Some of Neesen's pumps, and that used in the Weston lamp factory in New York, also have this device; but these belong to the sub-class of shortened pumps, and are described below.

* Couttolene. "Comptes Rendus," xci., 920, 1880.

† Diakonoff. See Karavodine.

‡ Bessel-Hagen, *loc. cit.*

§ Karavodine. "Journal de Physique," S. II., vol. ii., 558, 1883.

‖ Siemens and Halske. D. R. patent, 28,579, Jan., 1884. For the accompanying sketches of the pumps the writer is indebted to Herr Von Hefner Alteneck.

¶ Sundell. "Wied. Beibl.," ix., 193. 1885.

Mr. Swinburne,* who has had extensive experience with pumps of several kinds, has described a form in which this principle is applied. Swinburne's first form, though provided, like Toepler's, with a fall tube, had also an automatic valve above the pump head. Fig. 31, taken from Swinburne's paper in the *Electrician*, shows this valve situated above a small cavity, C, separated from the pump head by a constriction, the object of which is to prevent the glass bottom of the valve being broken by the sudden rise of the mercury. The eject chamber, E, is connected through a tap, L, to a horizontal pipe, marked F in this cut. This pipe,

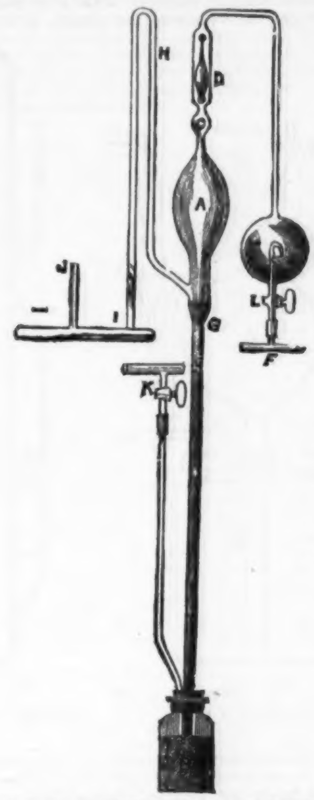


FIG. 31.—SWINBURNE'S PUMP.†

which runs along a whole range of pumps in the pump room of the lamp factory, is mechanically exhausted, and the use of the tap, L, is to start the action of the pumps. After this the action is kept going by a three way tap (here marked K) which connects the cavity above the mercury in the supply vessel alternately with the atmosphere and a supply of compressed air. In a later form, Swinburne's pump has a siphon mercury trap between the pump head and the automatic valve above it. When the exhaustion has been carried far enough, the mercury is lowered and raised some ten or twenty times, just so far as to drive the residual air through the mercurial siphon, which then will show a small back pressure—perhaps of only one or

FIG. 32.—SWINBURNE'S PUMP (LATER FORM).

two centimeters. If the volume of the pump head is many times as great as that of the cavity beyond the mercury trap, and if there be a fairly good vacuum beyond the trap, it is obvious that a back pressure of one or two centimeters as the result of twenty strokes may mean a very high degree of exhaustion. Swinburne remarks that the bore of the siphon tube used as a trap must be not larger in the descending part than in the part that ascends to the supplementary chamber.

CLASS IIIa.—SHORTENED UPWARD AND DOWNWARD DRIVING PUMPS.

Swinburne's pump just described might, if worked intermittently with an exhausting instead of a compressing pump, be transferred to the category of shortened pumps.

Probably the most perfect of pumps in this class is that of Prof. F. Neesen,‡ of Berlin. This indefatigable worker has introduced, from time to time, several improvements. As mentioned above, he introduced the side tube, N, in 1878, and designed a double acting

* Swinburne. "The Electrician," xix., pp. 51, 71, 117, and 158, 1887; a series of papers giving a summary of valuable experience in exhausting glow lamps.

† This figure is kindly lent by the editor of *The Electrician*.

‡ Neesen. "Wied. Ann." iii., 608, 1878; *ib.* xi., 522, 1880; *ib.* xiii., 384, 1881; "Zeitschr. fur Instrumentenkunde," ii., 287, 1882; *ib.* iii., 245, 1883; also, "Wied. Beibl.," vii., 651, 1883. Figs. 33 and 34 are from sketches kindly furnished by Prof. Neesen.

Toepler pump in 1880. Independently of Mitscherlich, he introduced the automatic valve above the pump head. In 1882 he was already employing the recurved siphon trap, Q, between the pump head and the second chamber, M. His complete pump, as constructed in 1887, is shown in Fig. 33. The lower portion is constructed on Robinson's plan, air tight connections being formed at the three necks of the bottle, L, by the use of coned steel collars, that are cemented to the three tubes, and fit to coned adapters, cemented to the three necks. Steel screw caps clamp down the conical collars into their respective seats. The tube, Y, is put into alternate communication with the atmosphere and with a good mechanical air pump, so as to raise

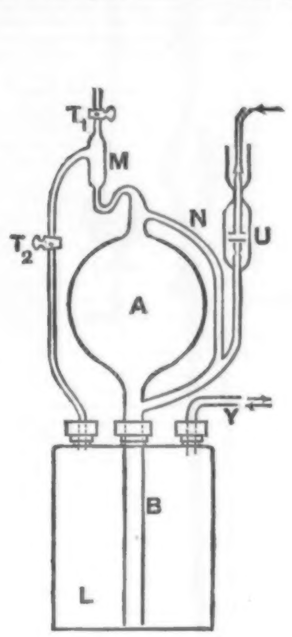


FIG. 33. NEESEN'S PUMP.

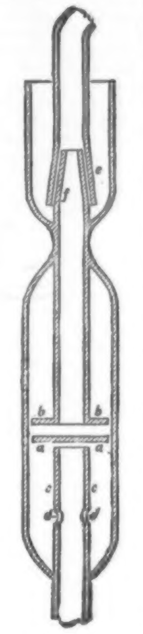


FIG. 34. FORM OF 1887.

and lower the mercury alternately in the pump head, A. There is an automatic valve, U, in the exhaust tube, which leads up to the drying flask and to the lamp or other vessel that is to be exhausted. This valve, which is shown enlarged in Fig. 34, is made somewhat on the plan of Schuller, described above, with a small glass disk about two centimeters in diameter, cut from thin plate glass, which, as the mercury rises under it, is pressed up against a flat flange, fashioned on the lower end of the upper tube. It works in a manner that leaves nothing to be desired. This pump is further provided with a chamber, M, and a siphon trap, Q, down which the residual air from the pump head is expelled into a moderately perfect vacuum.

Another very interesting and extraordinary pump belonging to this class is that of P. Clerc.* depicted in Fig. 35. The apparatus shown is connected by a

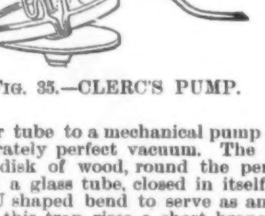


FIG. 35.—CLERC'S PUMP.

flexible rubber tube to a mechanical pump capable of giving a moderately perfect vacuum. The apparatus consists of a disk of wood, round the periphery of which is fixed a glass tube, closed in itself, but provided with a U shaped bend to serve as an air trap. At one side of this trap rises a short branch tube to which the lamp that is to be exhausted is sealed; at the other a similar branch tube leads to a bulb connected through a tap to the auxiliary pump. Enough mercury is placed in the tube to occupy about a quarter of the circumference and fill the trap.

The whole apparatus is mounted obliquely upon another disk of wood, in such a way that it can be rolled round on its periphery by means of a projecting central handle. A preliminary exhaustion having been attained, the tap is closed and the apparatus is rolled around. The mercury in the tube sweeps the air before it into the bulb, and, passing into the trap again, emerges to push a fresh quantity from the lamp in front of it, leaving behind every time in the trap a sufficient quantity of mercury to balance the difference of pressure between the bulb and the lamp. The quantity of mercury required for this apparatus cannot exceed a few cubic centimeters at the most.

Fig. 36 † represents the pump used in the lamp factory of Mr. Weston, at Newark, New Jersey. The second chamber, M, connected with the pump head by the siphon tube, Q, will at once be recognized, as also the automatic valve, U, in the exhaust tube. The mercury in the supply vessel, S, is raised and lowered by alternately connecting the upper part of the vessel through the three-way tap, Y, with a mechanical exhaust pump, and with the atmosphere. The top tap is only used when the chamber, M, has to be put into communication with the mechanical pump. The other taps are safety taps, not used during the working of the pump. The tap between the lamps and the valve, U, is worse than useless.

* Clerc. "Dingler's Polytechnisches Journal," cclxii., Part II., 1886; also "Zeitschrift fur Instrumentenkunde," vi., 403, 1886; and D. R. P. 36,447 of 1885.

† For this sketch the writer is indebted to Prof. G. Forbes.

CLASS IV.—COMBINATION PUMPS.

It has been suggested by Edison* and by Bohm† to combine a Geissler pump with a Sprengel pump in the endeavor to obtain a more perfect result. This method of combination, which consists merely in sealing the exhaust tubes of each pump together and to the lamp, cannot be commended. If the Geissler exhausts more perfectly than the Sprengel, or *vice versa*, then the other pump is useless. A much more hopeful combination has been suggested by Mr. J. T. Bottomley,‡ who

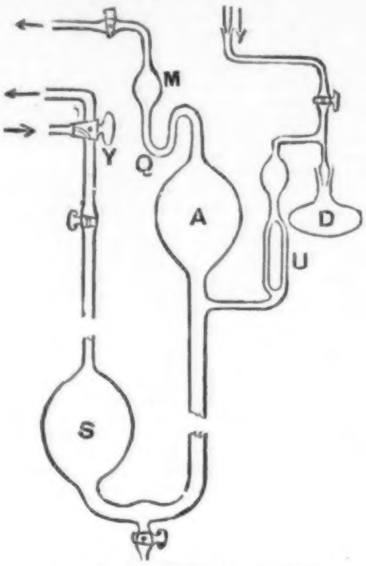


FIG. 36.—WESTON'S PUMP.

proposes to utilize a Geissler arrangement to exhaust the chamber into which the foot of the fall tube of the Sprengel is led, thus putting the two pumps into series.

CLASS V.—INJECTOR PUMPS.

There are a few pumps depending for their action upon the principle of the injector, the degree to which they exhaust depending upon the velocity of efflux of mercury from an orifice, as in the original injector of Hauksbee. The earliest of these were designed by Cavarra § and Plateau.‖ Another form, exhibited in 1876 at South Kensington, was invented by Prof. Von Feilitzsch,¶ in which two cylinders, fitted with pistons, worked by cranks, drove a mercury blast through suitable jets and drew in air, so creating a vacuum. It exhausted down to a pressure of 1 millimeter, or about 1,300 millionths of an atmosphere.

Several other injection pumps of the centrifugal species were described by De Romilly** in 1881, one of them being designated as a *pneole*. Nothing is known to the writer as to its performance.

CLASS VI.—MECHANICAL MERCURIAL PUMPS.

Only one pump is known to the writer as coming definitely within this category; and this is a pump designed and constructed by Mr. J. Wimshurst, and of which no account has hitherto been published. It consists of an endless chain of little steel buckets, which pass up one barometric column and down another, within steel tubes containing mercury. Below, they enter a mercury bath, where they pass under two square pulleys, rising over a higher driving pulley between the two. The buckets as they descend, mouth downward, carry down air from above the top of the barometric column, and discharge themselves as they come up in the mercury bath. Owing to the fact that it has hitherto been found necessary to employ oil as a lubricant, the power of this highly ingenious apparatus to produce a vacuum is limited.

There are a few pumps concerning which the writer has not been able to obtain information, including those of Diakonoff, Neveux, Pfluger, and Southby, which are known to him by name only.

RESULTS.

The results that have so far been obtained by various pumps may be briefly tabulated as follows; the vacua produced being specified both in millimeters and in millionths of one atmosphere.

Authority.	Nature of Pump.	Pressure in millimeters of mercury.	Pressure in millionths of one atmosphere.
Crookes	Improved Sprengel (maximum result)	0·000046	1/17
Gimingham	Single fall Sprengel, 1·1 millim. diam.	0·00051	2/3
"	Five-fall Sprengel	0·000006	1/125
Rood	Plain Sprengel	0·000152	1/5
"	Rood's Sprengel, heated	0·000002	1/380
Bessel-Hagen	Old Geissler, after 25 strokes	0·110	145
"	New Geissler (2 taps) after ditto (average)	0·0085	11
"	New Geissler (2 taps) (maximum result)	0·0082	10⅘
"	Old Toepler, after five strokes	0·0075	10
"	" after five more	0·0064	8
"	Modified Toepler (average)	0·000012	1/63
"	" (maximum result)	0·000008	1/95

If Rood's method of measurement be correct, the results attained by him are very remarkable.

* Edison. "Scribner's Monthly Magazine," Feb., 1880, p. 538; "English Mechanic," xxxii., 117, 1880; see also Urbanitzsky, "Das Elektrische Licht," 1883, p. 56.

† Bohm. See Merling's "Elektrische Beleuchtung," p. 394, or Urbanitzsky, *op. cit.*, p. 63.

‡ Bottomley. "Rep. Brit. Assoc.," 1886, Birmingham meeting, p. 519.

§ Cavarra. "Comptes Rendus." 1843

‖ Plateau. Hervorbringung eines Vacuums mittelst der Centrifugalkraft des Quecksilb. "Pogg. Ann." 151. 1843.

¶ Von Feilitzsch. Theorie und Construction einer hydrodynamischen Luftpumpe. Greifswald, 1876. See also "Mitth. des naturwiss. Ver. v. Neupommern und Rugen," ix., 1887; and Catalogue of Loan Collection of Scientific Apparatus (1876), p. 134.

** F. De Romilly. "Journal de Physique," Ser. 1, vol. x., 303, 1881; Ser. 2, vol. iv., 386, 1885.

CONCLUSION.

On comparing the experience of various workers, it seems as if the best class of pump for the production of such vacua as are required for lamps is the third class, as modified so as to drive the air up the pump head and down a simple short barometric trap into an already partially exhausted chamber. No one appears to have yet tried a shortened Sprengel with a crook in the fall tube. The writer offers it as a suggestion. Further, if the experiments of Rood are worth anything, they indicate that an immense advantage is gained by working with pumps heated up above the boiling point of water. The "absorption" of gases and vapors against the surfaces of glass and mercury in the working parts of the pump is certainly much less hot than cold. Why should not all pumps be so constructed as to enable this method to be adopted? Since much seems to depend on the point of mercury, why should not the mercury be distilled direct into the pump? Whenever cements are used, why should not some plastic inorganic substance, such as chloride of lead or tungstate of lead, be employed, instead of resin, pitch, or other organic body, which will give off vapors? Lastly, if the device of exhausting into an already fairly well exhausted chamber so greatly improves the degree of rarefaction attainable, why should we not carry this process one or two stages further, and relay a series of pumps one working into the other? Such a process would resemble those processes of successive operations which have been called "Pattinsonization;" and it is possible that it might yield results surpassing anything yet attained.

In surveying the literature of the mercurial air pump, one cannot but be struck with the immense number of workers who have contributed to the invention, and the number of details that have been independently reinvented by different individuals. The literature of the mercurial pump affords, indeed, a striking proof of the fact that inventions grow rather than are made. The invention is essentially the product of the age in which it appears, a necessary consequence of the inventions and discoveries that have preceded it. The scientific method of investigating historical events has shown us how false, how childish, is the "great man" theory of history, which was taught—and alas! is taught still—to us at school. But if the great man theory of history is fallacious, so is also the great man theory of inventions. There were steam engines before Watt, locomotives before Stephenson, telegraphs before Wheatstone, telephones before Bell, gas engines before Otto. It may be that occasionally an inventor strikes upon a valuable or useful improvement; it is exceedingly rare for an absolutely original invention to be sufficiently perfect to be of immediate use. Of the essential insufficiency of the great man theory of inventions, the literature of the mercurial air pump affords a most striking proof.

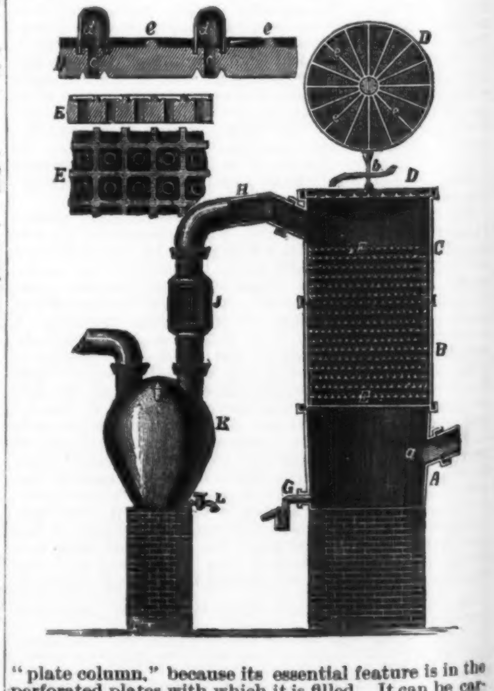
The investigation of this literature, which has long occupied the writer, has been a fascinating pursuit, partly because of its unexpected richness, partly on account of the fascination of the subject. Every one who has worked with mercurial air pumps must acknowledge to a kind of fascination in watching the ebb and flow of the liquid metal, and in speculating on the nature of the actions that go on in the vacuous spaces. It was, perhaps, with some such sense that Hauksbee, after describing one of his physico-mechanical experiments, wrote these words: "Such a dense and polite body is mercury; such a subtile mover is air; and such an apt repository is an exhausted receiver."

A NEW APPARATUS FOR CONDENSING GASES BY CONTACT WITH LIQUIDS.

By G. LUNGE.

THE problem of condensing gases by contact with liquids is one which is presented in a very large variety of cases.

The following description and diagram will give an idea of the new apparatus, which I have styled the



"plate column," because its essential feature is in the perforated plates with which it is filled. It can be carried out in many shapes, and can be made of any suitable material, but so far it has only been made of that kind of stoneware which is the specialty of Mr. Rohrmann. It is unnecessary to say that the material must offer the greatest possible resistance both to the action of acids and to changes of temperature, but it should also admit of a great deal of nicety in mould-

ing every detail. For some purposes such apparatus might be made of metal, or even of wood lined with lead, especially when it is made of a larger size than can be well done with stoneware.

The plate column, in that shape which is now preferably made, consists of a number of earthenware cylinders of as large diameter as can be conveniently turned out. It is now made 72 centimeters (say 2 ft. 5 in.) wide. The bottom is formed by a trough, A, with an outlet for the liquid, and an inlet for the gas, *a* (compare diagram). This bottom trough is surmounted by one or more cylinders, B C, which contain the perforated plates, and at last by the top cylinder, D, provided with an outlet for the gas, H, and an arrangement for spreading the condensing liquid. That liquid (in the majority of cases, water) is run from a store tank on to the cover of the column, and is spread out by means of the self-acting "acid wheel," *b*, all over the divisions produced on the cover by the radial ledges, as seen on the plan, D. The water runs off by the holes, *c*, closed by the cups, *d*, serving as hydraulic seals, and the bottom of the cover is so shaped that the liquid must drop out of each single hole without spreading along the under side of the plate. By this means the liquid is forced to drop quite regularly all over the area of the column, and to cover the whole surface of the uppermost of the plates, E E.

Except the last mentioned arrangement, there is nothing novel in the construction of the cover. Indeed, any other suitable means for spreading the liquid quite evenly all over the area of the column might be employed. But the peculiar feature of my apparatus appears in the plates, E E. Each of these is covered with a network of small ledges, and in each of the squares thus formed there is a perforation, with a somewhat raised margin. The height of that margin is not quite as great as that of the ledges, hence there is always a layer of liquid, about ⅛ inch deep, in each of the squares, and as there is always more liquid dropping in, the excess is forced out through the perforations drop by drop. The plates are not identical in shape, but differ as to the position of the holes. To each perforation in any one plate there corresponds the point of union of the ledges in the plates above and below. Hence the liquid cannot drop straight through the holes in the following plates, but strikes the solid portion of the next plate, is scattered about, and is divided among the adjoining squares. This action is repeated from plate to plate. Thus the thin layer of liquid resting upon the plates and clinging to the holes is constantly renewed, and by the scattering about of the liquid another absorbing surface is created.

The gases and vapors rising within the column pass through the numerous holes of the lowermost plate, and are thus divided into a great number of fine jets. Immediately on issuing through the holes of this plate, they strike against the solid places in the next plate above, which correspond to the holes, and are thus divided and mixed again; and this process is repeated as many times as there are plates provided. While the gases and vapors thus travel upward in continuously renewed mixtures, they come into the most intimate contact with the absorbing liquid, which they meet within the narrow holes on the plates and scattered all over in fine drops. By the incessant changes in the direction of the current, and the equally incessant renewal of the surface of the liquid, the most favorable conditions are produced for a mutual action of the gaseous and liquid substances. Owing to the principle of the apparatus, no false channels can exist, in which the gases or liquids would travel separately without coming into proper contact with each other.

This circumstance partly accounts for the enormous difference in condensing power between the "plate column" and a perfectly well constructed and packed coke tower, or any similar apparatus, fitted with pieces of pottery and the like. The liquid within a coke tower is never quite evenly distributed. There are always many places where it drops down a considerable height without meeting a piece of coke, and where, on the other hand, the gases find channels in which they can ascend without for some time getting mixed and coming into contact with liquid. Moreover, the individual gas channels are too wide, and the inner portion of the gaseous current does not enter into reaction with the absorbing liquid. This is unavoidable, because the interstices between the pieces of coke are quite irregular, and therefore the section of the tower must be made wide enough, and the pieces of coke large enough, to secure a sufficiency of draught for the worst case. Nor, as experience has demonstrated, have any arrangements of pieces of pottery hitherto had a better effect than coke. Hence, coke towers must be made very wide and high, thus offering a long time and corresponding opportunities of mixing the gases and contact with liquid; and in this way the reaction is certainly very complete at the end. But this enormous enlargement of space can be avoided by the systematical way in which, in my new apparatus, the gaseous current is split up into upward of a thousand very thin and exactly equal jets, which must continually alter their direction, and must, therefore, be thoroughly mixed every time they pass through a new plate. On their way they come into the most intimate contact with constantly and systematically renewed thin layers of liquid. The network of ledges prevents any unequal downward passage of the liquid, differently to the action of coke towers or of any other hitherto known form of similar apparatus. Perhaps a still more important difference is the following: That there is a very thin and constantly renewed layer of liquid standing on each plate, and that the gases, in passing through the perforations of the plate, must frequently break through the drops of liquid. This seems to produce an action somewhat similar to the Coffey still, or other "rectifying" apparatus, and it may, to a great extent, explain that such an intense action takes place in so small a space.—*Jour. Soc. Chem. Industry.*

ATTEMPTS have been made to make Edelweiss, the beautiful Alpine plant, grow among the Riesengebirge mountains of Bohemia. Experiments have also been made at Eifel, and especially among the ruined castles of Nurling. It is thought that the plant is changing its character, being transformed into new species. Such a transformation has occurred in the mountains of upper Austria, and instead of the beautiful ermine-like white bloom, the flower has become red.

MAKING GOLD AND SILVER SALTS FOR PHOTOGRAPHIC USE.

By H. C. S.

As the salts of gold and silver used in photography are expensive to buy, and their manufacture is not difficult, even if undertaken by a non-chemical person, if he follow closely the directions about to be given, I have thought it might be of interest to the readers of the *Camera* to give directions for making the nitrate of silver and the terchloride of gold salts which are used in photographic manipulating. First, with regard to chloride of gold, or auric chloride. There are two chlorides of gold—the protochloride and the terchloride. The latter salt is the one used in photography. The chemical formula of the protochloride is $AuCl$, and that for the terchloride is $AuCl_3$ (that means that in the terchloride there is three times as much chlorine united with the same amount of gold as that in the protochloride). The terchloride is the most important compound of the metal. It is always produced when gold is dissolved in a mixture of nitric and hydrochloric acids. Gold is not dissolved by any simple acid, nor by any other liquid than this nitro-hydrochloric acid. The deep yellow solution produced by dissolving gold in this compound acid yields by evaporation yellow crystals of the double chloride of gold and hydrogen. When this is cautiously heated, hydrochloric acid is expelled, and the residue on cooling solidifies to a red crystalline mass of terchloride of gold, which is very deliquescent (that is, it imbibes moisture), and is soluble in water, alcohol, and ether. The terchloride combines with a number of metallic chlorides, forming a series of double salts. These compounds are mostly yellow when in crystals, and red when deprived of water. A mixture of terchloride of gold, with excess of bicarbonate of potash or soda, is used for gilding small ornamental articles of copper. These are cleaned by dilute nitric acid, and then boiled in the mixture for some time, by which means they acquire a thin but perfect coating of reduced gold.

The yellow needle-shaped salt usually obtained by evaporating the acid solution to the crystallizing point is an acid chloride (formula $HClAuCl_3$). As it is not absolutely necessary that perfect purity of the chloride is essential for photographic purposes, the salt can be made from any scraps of gold ornament of 18 to 22 carats fine. It would not be worth while to employ a lower standard, since the larger amount of alloy in 15, 12, and 9 carat gold would too much interfere with the production of good terchloride; and, moreover, the small amount of gold present would not be of sufficient quantity to repay the trouble of manipulation. If small quantities of the salt be required, a book or two of gold leaf can be employed for its production. If larger quantities, a gold coin may be used. One word of caution, however. The defacement of a coin of the realm is punishable by fine.

The atomic weight of gold is 197, and that of chlorine 35·5—that is, 197 parts of gold unite with 35·5 parts of chlorine to form the protochloride ($AuCl$), and in the terchloride 197 parts of gold unite with 106·5 (*i. e.*, 35·5×3) of chlorine to form the auric chloride ($AuCl_3$); consequently, the combining weight of the latter salt is 303 5. The Australian gold coins are alloyed with silver, and therefore are preferable to those of the English mint, inasmuch as the silver is left in the shape of undissolved chloride, which can afterward be filtered out, whereas copper is much more difficult to get rid of.

Conversion of Gold into Terchloride.—Put into a long wine glass or thin narrow tumbler two fluid drachms of nitric acid to one ounce of hydrochloric acid—that is, the first acid is in the proportion of 1 to 4 parts of the latter. If the acids are of concentrated strength, a little water will be necessary to add to this mixture of acids; if they are of ordinary strength, water will be unnecessary. Place the glass vessel containing this mixture of acids in a saucer on the hob, so that, should the vessel crack, the liquid will not escape, or else place the vessel in a basin of hot water. The gentle heat afforded from either of these sources should be maintained until the gold is dissolved. Place the coin or scrap gold in the mixed acids, and stand on the hob, so that the fumes given off shall escape up the chimney. The above quantities of acid will generally be sufficient to dissolve a sovereign or its equivalent weight of scrap gold. If, however, the solvent action ceases before the gold is dissolved, add a little more acid. A great excess of acid should be avoided, because it renders their neutralization or subsequent elimination more difficult. If pure leaf gold be employed, the solution will form a perfectly transparent yellow liquid. In the case of the Australian gold coin, however, the small portion of silver alloyed with the coin will give a precipitate of chloride of silver, which will give a cloudy appearance to the liquid. Pour this solution of gold into a basin,* and add to it about six ounces of distilled water, and stir up the mixture with a glass rod. Next add some powdered chalk to the liquid to neutralize its acidity. The way to ascertain whether the acid is completely neutralized is to dip a piece of blue litmus paper or to drop a little tincture of litmus solution in the acid. If any acid be present, the paper will lose its blue color, and be colored pink or red. If the blue color remains unchanged, then you know the acid is completely neutralized. Stir the chalk well up in the liquid, and then filter it into a bottle thus: Take a piece of clean white blotting paper, cut it into a circular form, fold this in half, and then fold again, so that it forms a quadrant—a quarter of a circle. Open this paper out, and place it in a glass funnel. Just moisten it with a little distilled water, to keep it in its place, and then stand the funnel in the neck of a clean bottle, capable of holding the solution of gold that filters through. The chalk, having united with the acids, will have formed solid salts of lime, which are retained on the filter paper. The liquid solution that passes through is a solution of terchloride of gold, fit for use in photography. As light partly reduces the gold into the metallic state, it is best to keep the bottle in the dark, or else closely enveloped in black paper, pasted round it.

To obtain the terchloride in the crystallized state, the above solution must be evaporated until the salt crystallizes out in reddish crystals. As these crystals imbibe water if placed in a moist atmosphere, and then form a yellow solution again, they should be stored up in hermetically sealed glass tubes. These tubes are easy of construction, thus: Take a piece of soft glass tubing, about 12 inches long and ¼ inch bore; hold one-third of it in the flame of a spirit lamp or gas flame, twirling the tube round, so that it is uniformly heated. When the glass begins to bend, hold it away from the flame, and, holding the tube at both ends, pull them apart, like stretching a piece of elastic. The heated part of the glass will yield to the pull, and, stretching, become narrowed. Break the tube in two at this narrow part, and then hold each of these narrow ends in the flame for a few seconds, until the glass, recoiling on itself, closes the orifice. Put the crystals of terchloride in with a quill at the open end of the tube, and then close that by directing the flame of a blowpipe on the periphery of the orifice until the glass melts and closes the aperture. The stem of a clay tobacco pipe forms a good substitute for a blowpipe.

* I am presupposing the experimenter will prefer to use ordinary utensils, instead of buyin chemical apparatus.

NITRATE OF SILVER.

The chemical formula for nitrate of silver (known to chemists as argentic nitrate) is $AgNO_3$. It is one of the most important salts of silver. It is readily made by dissolving the metal in moderate dilute nitric acid, and concentrating the solution when it separates out in anhydrous tables belonging to the triclinic system. It dissolves in its own weight of cold water, forming a neutral solution, which is partly reduced by the action of hydrogen with the production of metallic silver to silver nitrite. It is soluble in alcohol and ether. It melts at about 224°. It rapidly attacks and destroys organic matter, and acts as a violent corrosive poison. It stains the skin, hair, etc., black. The salt blackens when exposed to light, more especially if organic matter of any kind be present. (To prevent this decomposition, the bottles containing the crystals should be covered with paper, as previously directed.)

Pure nitrate of silver may be prepared from the metal alloy with copper—such, for instance, as common silver ornaments not made of pure silver. The alloy is dissolved in nitric acid, the solution evaporated to dryness, and the mixed nitrates cautiously heated to fusion. A small portion of the melted mass is removed from time to time for examination. It is dissolved in water, filtered, and ammonia added to it in excess. While any copper salt remains undecomposed, the liquid will remain blue, but when that no longer happens, the nitrate may be suffered to cool, dissolved in water, and filtered from the insoluble black oxide of copper.

Nitrate of silver is sometimes adulterated with nitrate of potash, and occasionally contains traces of copper and lead. When precipitated by a slight excess of hydrochloric acid, the filtered solution ought to leave no fixed residue when evaporated on platinum foil, as the whole of the silver would be thrown down, and any impurity would remain in solution. Copper is detected by adding ammonia in excess to the solution, when it will give the liquid a blue tinge.

Production of Nitrate of Silver.—$AgNO_3$ (atomic weight equal 170; *e. g.*, atomic weight of Ag is 108; atomic weight of N is 14; atomic weight of O_3 is 48). Nitrate of silver can be made from scraps of silver articles of jewelry, for although silver ornaments are made of silver alloyed with another metal—usually copper—yet the nitrate of silver can be obtained pure by the processes described below. Since, however, the heat which is necessary to decompose the nitrate of copper often produces nitrite of silver, it is advisable that silver nearly free from copper should be chosen in preference. Indian wrought silver articles are, I believe, pure silver.

The ordinary commercial silver nitrate, since it is obtained as a by-product in the operations of parting gold and silver which are carried on in the refineries, and also in many assay processes, the necessary careful attention for the production of a pure nitrate is not always bestowed on it. Too frequently the crystals are sent out simply dried off from the nitric acid; and in other cases, owing to the addition of charcoal to the vessel containing the silver solution, it is not unfrequently that particles of charcoal, oxidized by nitric acid into a body which shows great affinity for the silver, are also present. Consequently, commercial nitrate of silver should be purified by recrystallization. Perhaps the best article to use would be a silver coin, the standard coin of the realm being an alloy of silver and copper in which silver is present to the extent of 92·5 per cent.

To Prepare Nitrate of Silver.—Put a piece of silver into a thin glass beaker or retort, pour on it some pure nitric acid, and support the vessel over a spirit or gas flame. If a beaker is used, an iron wire triangle high enough to reach over the top of the spirit lamp can be used, on which place a piece of iron wire gauze, and then stand the beaker containing the silver and acid on top. (A spirit lamp can be bought for 1s., the triangle for 4d., and the wire gauze for 3d., and can be obtained from or through any dispensing chemist.) If a retort is used, a ring stand should be employed to hold it. Continue heating the acid until the coin is dissolved, and crystals appear. Take these crystals out of the vessel, put them into a saucer, and pour on them a little dilute nitric acid, and then redissolve them in water, and crystallize by evaporating this aqueous liquid. A porcelain evaporating dish is the best article to employ for this purpose, or it may be done in a saucer placed on a shovel held over a fire. If the nitrate is not wanted in crystals, it can be obtained thus: After having dissolved the coin in the nitric acid, boil this impure acid solution until a dry mass is obtained, without becoming crystalline, for which purpose the beaker containing this acid and dissolved silver can be stood in a saucepan containing water, and the water allowed to boil, care being taken that it does not boil over into the beaker. Put this dry mass into a crucible (bought for a few pence) and fuse it pretty strongly. This fusing can be performed in this manner: Make a good, clear coke fire, and stand the crucible in an iron spoon or ladle in the fierce part of the fire, until the fusion is complete. Take out a portion of the fused mass from time to time and dissolve it in water, and then filter the solution thus obtained, to free it from oxide of copper, and to the filtered solution add a little ammonia. If a blue color is produced, the fused mass contains nitrate of copper still incompletely decomposed. In such case continue the fusion until a portion taken out and treated as just mentioned ceases to give

a blue coloration to ammonia. When this occurs, dissolve the fused mass in water, when it is ready for use, or can be recrystallized as already described.

Another process for obtaining nitrate of silver from an alloy of copper and silver is to dissolve the alloy in nitric acid and suspend a piece of clean metallic copper until the silver is wholly precipitated. Take out the copper and wash the silver in plenty of water. This washing is performed by adding water, stirring the precipitated silver salt, and pouring the solution into a filter, and then keep adding water to the mass in the filter. Collect the precipitate off the filter paper, and add to it a little solution of nitrate of silver to remove any adhering particles of copper. Finally add some nitric acid to the precipitate, and crystallize by evaporation. A third process is to precipitate the silver from the coin by immersion of a piece of copper in the acid solution (as just directed in last experiment), wash the precipitated silver in nitric acid (being careful not to add an excess of acid; if excess has been added, evaporate carefully to dryness to expel it); then to neutralize and remove traces of the copper salt, add oxide of silver to the boiling solution (of precipitated silver and nitric acid), and filter it. When the filtrate ceases to give a blue coloration to ammonia, the nitrate may be looked upon as pure. This solution, if of the right strength, might be used at once for photographic purposes.

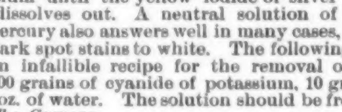
The purity of nitrate of silver may be easily ascertained by dissolving a portion in distilled water, and precipitating the solution entirely with pure hydrochloric acid. The liquid filtered from the precipitate should leave no residue on evaporation to dryness. Mr. Taylor, an authority in photographic chemistry, says: "Nitrate of potash and nitrate of copper would have little effect, except in reducing the strengths of the bath. The peculiar photographic action of bad nitrate of silver is probably to be referred to a different source, viz., to the presence of oxidized organic matter. In the assay process" (of obtaining this silver salt) "fragments of charcoal are introduced to prevent the acid from bumping in the vessel as it dissolves the silver. We have good reason for believing that during this process the nitric acid oxidizes the charcoal into a substance which has an affinity for the silver salt." And Mr. Taylor has found that nitrate of silver so produced is altogether unfit for collodion photography. "The fact is certain, that nitrate of silver prepared by dissolving silver in nitric acid and evaporating to dryness without any crystallization cannot be depended on for photography." In this case recrystallization of such salt should be resorted to for obtaining the nitrate in a fit and pure state. A saturated solution of the purified crystals slowly restores the blue color of reddened litmus paper if the nitric acid be expelled by heating to 240° previous to the second recrystallization. This proceeding, however, is not actually necessary, inasmuch as a trace of adhering nitric acid can always be removed by carbonate of soda when making the bath. The action of light upon nitrate of silver is very peculiar. If pure, it may be kept unchanged in the crystallized form, or in solution in distilled water; but if the solution contain vegetable or animal (organic) matter, the nitrate is decomposed and blackens. The stains upon the skin produced by handling nitrate of silver are produced in this way, and are seen most evidently when the part has been exposed to light. The varieties of organic matter which especially facilitate the blackening of nitrate of silver are such as tend to absorb oxygen.

Removal of Silver Stains from the Flesh.—A lump of moistened cyanide of potassium (a deadly poison) may be rubbed on the stains caused by manipulating with nitrate of silver, provided the flesh is not cut or the skin torn. Let it remain on the hands for a short time, and then well wash it with water. Another method is to make a solution of iodide of potassium, and place on the stains, permitting this to dry on, and when the black stains have been converted into yellow iodide of silver, wash the hands with a little hyposulphite of soda.

To Remove Silver Stains from Linen.—Put a little iodine into a solution of iodide of potassium, and rub this on the stains, afterward washing them out with water and soaking in hyposulphite of soda or cyanide of potassium until the yellow iodide of silver that is formed dissolves out. A neutral solution of bichloride of mercury also answers well in many cases, changing the dark spot stains to white. The following, however, is an infallible recipe for the removal of silver stains: 100 grains of cyanide of potassium, 10 grains of iodine, 1 oz. of water. The solution should be free from color.—*The Camera.*

BRUSHING MACHINE FOR HORSES.

A NEW brushing machine for horses, cattle, etc., has recently been brought out by Fritze & Co., Copenhagen. This appliance has already made a host of



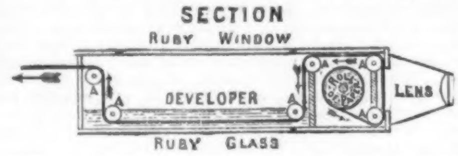
friends, and it appears to give general satisfaction. A number of flattering testimonials from different veterinary authorities and practical horsemen have been received, and the machine seems to have supplied a want. It is claimed to possess several important advantages over the old style of grooming. In the first place, the groom can thoroughly overhaul the horse in a quarter of the time required when using an ordinary old fashioned brush, and the cleansing is far more efficient. Besides, this new machine makes it possible to clean the horses in places where it was almost impossible to reach before. Especially for old and less well conditioned horses the machine is claimed to be a great boon, and the horse very soon gets accustomed to the machine.

KENNAN'S ACTINOMETER.

I PURPOSE for the above an apparatus in one or more parts, enabling a sensitive surface to be exposed and afterward developed.

A small dark back, measuring say about 3½ in. by 1½ in. by 1½ in. deep, holding a number of slips of the brand of plate in use by the photographer. In front of this back there would be a slide carrying a small lens having stops of any standard aperture. This would slide up and down in front of one of the sensitized plates, so that, say, three exposures could be made on a slip measuring 3¼ in. by 1 1/16 in. (a ¼ plate cut in four). A small bath (either made of ruby or yellow glass, or

SECTION



with a piece let in to serve as a window) would be slid, or otherwise placed, so as to receive the exposed slip, and this bath would contain a developer, say a standard oxalic developer. The effect of the different exposures could be watched while developing, and, of course, the proper exposure would be at once determined on. The developer could be carried either in the little bath, using a vulcanized cover, or in a vulcanized ball.

The above apparatus could be easily made very light and portable, but I suggest the advisability of using negative paper in place of glass. This could be used, say one inch wide, rolled up, and would be made to pass behind the small lens, thence, after exposure, into a trough or bath containing the developer, and from that to the outside of the apparatus, where it could be examined. The latter apparatus could be made to measure only 4 in. long by 1 in. square, as per rough sketch.—*Photographic News.*

A NEW VACUUM PAN.

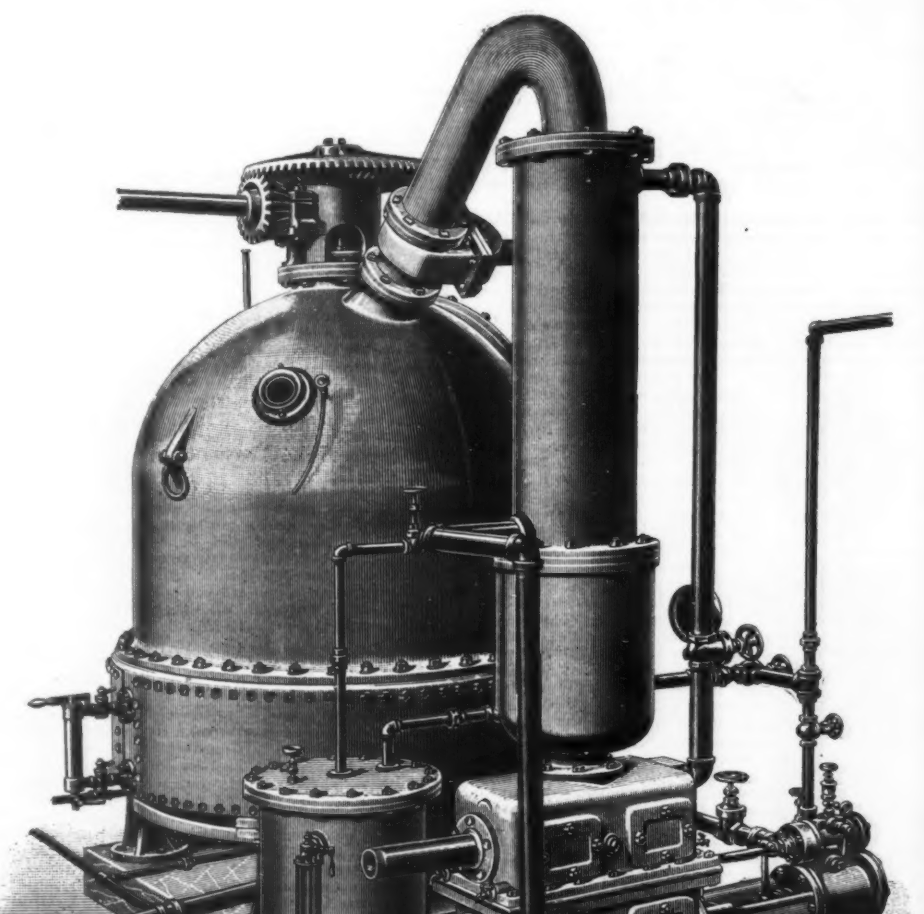
OUR illustrations are from *Engineering*, and represent a pan and helix condenser for dehydrating crude or refined glycerine. This pan has produced material of the highest specific gravity of any known pan in dehydrating the unrefined or distilled product, viz., to 1·26637—the monohydrate being 1·2670. A process called the Yar Yan claims as high as 1·264, which is, at the present time, the second best result obtained on a large practical scale. This machine differs from others in that it maintains an artificial circulation and keeps the heating surface free at all times from any deposit whatever, thus preventing carbonization of delicate products.

The particular object in view is to take up the work of the ordinary coil vacuum pans at a point where ebullition ceases and the charge adheres to the coils. This the machine accomplishes readily, as it is free from coils, joints, stay bolts, etc., and is provided with a set of adjustable knives that keep the heating surface free at all times. It is a combined vacuum pan, mixer, and cooler.

The bottom jacket is so constructed that it admits of a high pressure of steam, allowance being made for expansion and contraction when cold water is admitted in place of steam, for cooling the charge. The side jacket serves for utilizing the exhaust steam from the vacuum pump, but may be heated by direct steam. The shaft is hung on a non-friction bearing outside of the pan, and the scrapers are regulated from the top of the shaft without breaking the vacuum.

Referring to the illustrations, Figs. 1 to 8 show the details, while the general appearance of the pan is illustrated by the perspective view. Fig. 1 is a vertical section, Fig. 2 shows the manhole cover, Fig. 3 the central shaft, Fig. 4 a plan of the scraper and stirrer, Fig. 5 a transverse section of the stirrer with the scraping knife attached, Fig. 6 a plan of the knife for scraping the stirrer shaft, Fig. 7 a modification of Fig. 5, Fig. 8 the means for adjusting the vertical shaft and scrapers, and Fig. 9 the method of suspension of the shaft.

The lower part of the pan A^1 has a circular jacket, D, which is divided by a vertical partition so that the steam or other fluid passsing through it must travel all round before it reaches the exhaust outlet. There is also a double bottom to the pan stayed with vertical ribs, B B, crossing each other at right angles. The upper portion, C, of the pan is strengthened by ribs, G G^1, which carry a boss through which the stirrer shaft passes. This shaft is made in three portions, the upper and the lower being solid, while the central portion is tubular and affords a passage by the holes, *k k*, for the products of evaporation to pass to the condenser. The lower part of the shaft revolves in a bearing, C^2, in the cross stay, C^1, while its point is guided on a pin. The upper part of the shaft is driven by bevel gear (Fig. 9), and its weight is supported on a ring of conical rollers, R. The shaft can be adjusted vertically by a screw by which it is hung from the wheel, O (Fig. 8), and in this way the scrapers, N (Fig. 5), can be set near to or further from the bottom of the pan. These scrapers are fixed to a stirrer bar, M, which runs across the bottom of the pan and turns up at each end parallel to its sides. Upon the bar there are also mounted vertical arms, S S, which rotate between the fixed arms, T T, depending from the bar, C. A



NEW VACUUM PAN AND EVAPORATOR.

fixed scraper, T (Fig. 6), removes the material which accumulates on the central shaft.

The condenser is the first of its kind attached to any pan. It involves the principle of a stationary helix with centrifugal separation of the heavy from light vapors, and was first introduced by Mr. Thomas Gaunt, an American engineer of some note, who demonstrated its efficiency on a larger scale in applying it to the great triple effect built by the Delamater Iron Works, of New York. Should mechanical action carry over anything of a greater specific gravity than the product evaporated, the force of the vapor current following the sharp curves of the double helix throws the heavy particles to the outside of the inclosing tube, and they are recovered in the base of the condenser. This principle is now, we believe, used for securing drier steam.

Considerable success has attended the introduction of this new apparatus, and a number of gold medals were awarded the products made in it. The gold medal for condensed beef was awarded a firm using this plant at the International Health Exhibition, London, 1884.

It has successfully dried *in vacuo*, to within an inch of the barometer, the following, viz., blood, tankage, fish refuse, bark extracts, licorice, glycerine, butter and oils, beef, antimony, sulphides, gluten, prepared foods, milk, soluble food, beef peptonoids, pepsin, etc., and distilled glacial acetic acid. There is no nuisance, smell, or annoyance from the machine after it is once closed.

Constructed at New York, by Messrs. C. N. Delamater & Co.

THE DALRYMPLE-HAY CURVE RANGER.

The Dalrymple-Hay curve ranger is an instrument by which curves can be laid out without reference to tangential tables. Once it is fixed at the commencement of the curve, and is adjusted to the desired radius, the finding of a series of points one chain apart along the arc is a simple mechanical process which can be carried out with celerity and with the greatest accuracy. The instrument itself is shown in the perspective view herewith, and a diagram explanatory of its action is given below. On the latter, A and E represent the extremities of an 80 chain curve, and B the intersection of tangents drawn from these extremities. The instrument, adjusted to the required radius, is placed at A, and set to line on B. The screw, *b*, is then turned until the index, *h*, points to 1 on the scale behind it. This turns the telescope on a vertical axis into the line, A C, and a peg is inserted at C, at one chain distance from A. The index is then turned through another division, bringing the telescope into the line, A D, and a peg is driven at D, at one chain distance from C. So the process is continued for the points, 3, 4, 5, . . 10, when the curve again enters the straight portion of the line at E. Hence it will be seen that the instrument does away with all calculation, and converts curve ranging into a mechanical operation.

The essential feature of the apparatus is a roller, *a*, which runs in frictional contact with a table, *f*. This roller is mounted on a graduated spindle, *b*, at the other end of which is the index, *h*. The roller is caused to rotate by turning the telescope stand, and the long arm projecting backward from it, around a vertical axis by means of the screw, *k*. As the arm sweeps over the table, the roller is caused to revolve and moves the index, the amount of motion of the latter for a given angular movement of the arm depending upon the distance of the roller from the center. Now the spindle, *b*, is graduated, the marks corresponding to radii from 20 chains to 100 chains, and the roller is set to the mark corresponding to the curve which is to be ranged. When it is at the extreme end of the table, a very slight angular motion of the telescope will move the index over one division, and, on the other hand, when the roller is at the inner end, the telescope must be turned a considerable amount to get the same movement of the index.

DALRYMPLE-HAY'S CURVE RANGER.

This ingenious device forms the key to the whole instrument, which in its other features is very carefully designed. The various parts are clamped on to a central column by the screws, *d*, *e*, and *g*, and when these are relaxed can be turned in any direction. The clamp, *e*, carries a tangent screw, K, and the other clamp, *d*, a nut for the screw to screw into. The vertical axis of the instrument can be made to revolve, by releasing both these clamps. If the lower clamp, *d*, is alone secured, then the vertical axis can again be turned; but if both clamps are secured, a slow motion can be given to the vertical axis by turning the tangent screw, K. *g* is a clamp and *i* a slow-motion screw for the horizontal table, *f*.

When this clamp is loosened, the horizontal table can be made to revolve round the exterior of the fixed socket, but on tightening the clamp a slow motion can be given to the horizontal table by the tangent screw, *i*. There is slow-motion gear for moving the telescope in altitude. The vertical axis of the long cone can be brought into a vertical position by the four parallel

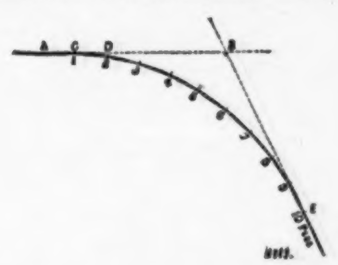
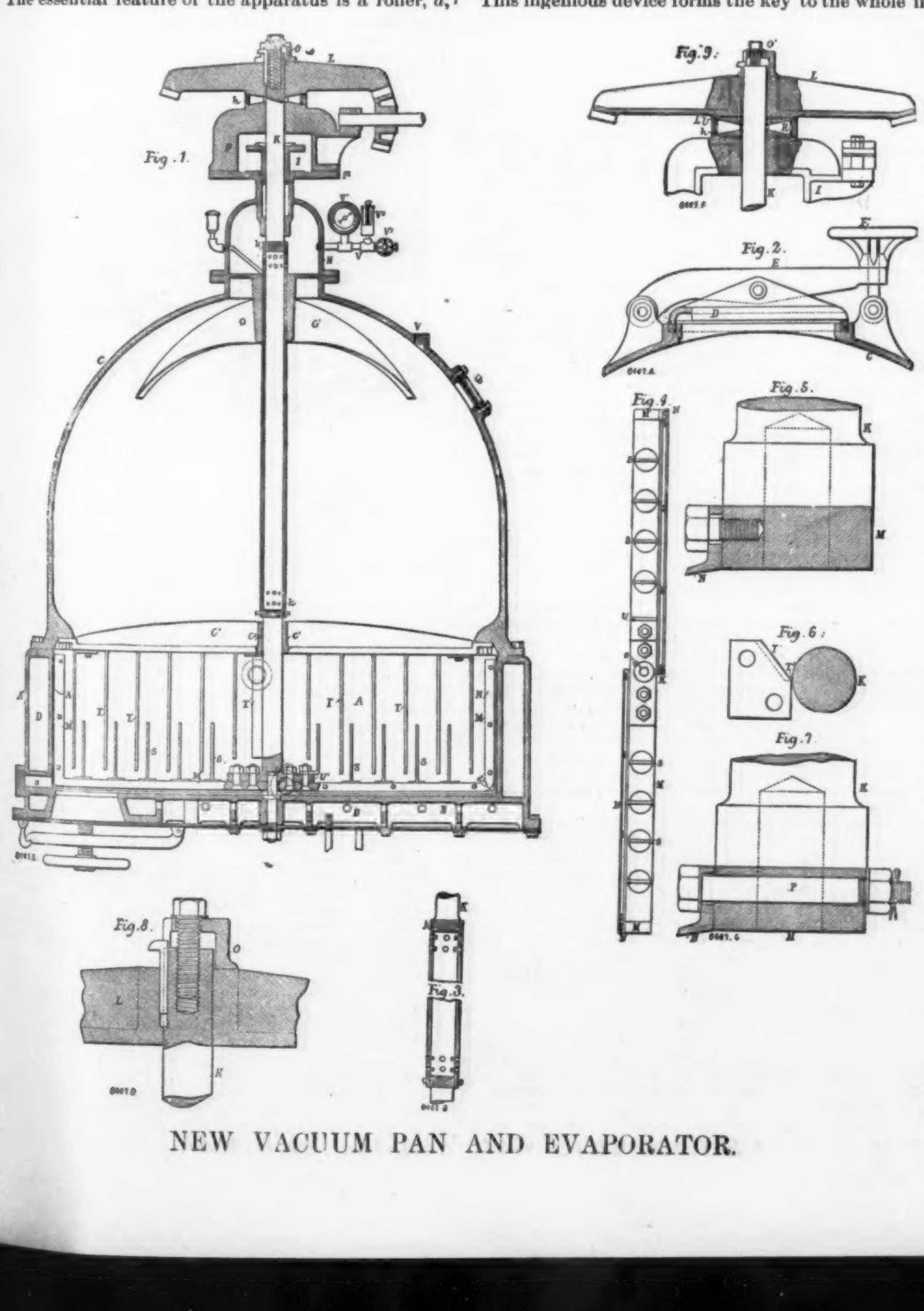


plate screws, and adjusted by means of the levels fixed to the Y's and on the telescope. The instrument is mounted on a tripod of the ordinary kind. There are two spirit levels for setting, and also two verniers by which vertical and horizontal angles can be read to one minute.

Although the spindle is only divided for curves from 20 chains to 100 chains radius, yet curves having radii either multiples or sub-multiples of any number on the spindle can be ranged. For instance, if the radius be 18 chains, then the roller is set to 36 chains, and the index, *h*, is made to pass over two divisions to each observation instead of one. Elliott Brothers, London, are the makers.—*Engineering.*



NEW VACUUM PAN AND EVAPORATOR.

PECULIAR ORIGIN OF FIRES.

When it is considered that there is not a process or method of manufacture which does not contain more or less the possibility of a cause of fire, and that these various processes differ one from another in the relative hazard, then it will conceded, says *Engineering*, that there is scarcely an element in the whole range of manufacture which is not in a like manner a factor in the question of safety and of insurance. The larger amount of losses is, as would naturally be assumed, due to oil, both in consequence of its imperfect use on journals and the hot bearings which result from a lack of proper lubrication. In the mechanical processes of dyeing and bleaching there is a great deal of chemical action, which at times results in ignition.

With such rapid machinery as that of the picker room in cotton, and the dusting room in paper mills, there is great liability of sparks. Such sparks are the antecedents of fires which occur among the light, textile, fibrous material found in such machines, and enormous fires occur from other causes which certainly entitle them to be classified as among instances of proverbial happening of the unexpected.

One large insurance company in America declares that their aggregated payments for fires caused by lanterns have reached nearly $2,000,000. The causes of these fires from oil are threefold, and they are all included in what an underwriter would call the preventable causes of fires. The use of lard or sperm oil of the very dubious purity generally offered in the market is always attended with a crusting wick; and many a watchman or repairing laborer in the night has unwittingly started fires caused by opening the lantern and picking the wick to remove the crust in order to get a better flame. For such lights, more satisfactory

results are obtained by the use of what is known as the signal oil, which consists of a mixture of animal oil and mineral oil.

In many places the instructions of the manager that the lantern should never be opened except in the boiler room or some similar place of safety are carried into execution by placing spring locks on the lantern which cannot be opened except by a key hung up in the boiler room. Other fires are caused by a lamp dropping out of a lantern. Any type of lantern where the lamp is placed in at the bottom is liable to such an accident, notwithstanding the method of construction may be such as to guard against that difficulty when new.

In some lanterns closed at the bottom, the globe at the top is removed in such a way that the hand reaches down to the light. In others the lamp of the lantern, although at the bottom, is secured in its place by a hinge, so that at worst, in case of any mishap, it would only swing down and not fall. The tubular lanterns, made solely for burning kerosene, have been the source of a great many fires by reason of poor methods of construction. They are soldered by an easily fusible alloy, and when such lanterns are hung up in places of unusual warmth, and the light turned up somewhat higher than usual, the upper part of the lantern sometimes becomes heated sufficiently to melt the solder, so that it falls apart. This is an accident entirely inexcusable when it is considered how readily lanterns are constructed without depending upon the soldered joint for the attachment of the handle to the body of the lantern, but use rivets, locked joints in sheet metal, and eyes bent in wire guards.

A curious lantern fire resulted in the burning of an American mill, and at the same time subjected an innocent person to an unjust suspicion. The facts were that the mill very suddenly burned at an early hour of the morning, the only direct evidence upon the case being that of the watchman, who testified that while making his round he entered the upper portion of the mill, finding the room in flames, but beyond control. There were many details of circumstantial evidence connected with the fire which convinced the underwriters that the fire was incendiary in its origin, and this, coupled with the fact that the mill had not been financially prosperous for some time, and also that the proprietor did not possess a reputation above suspicion in commercial affairs as to strict integrity, diverted a great amount of suspicion toward him.

This suspicion was not sustained by any direct evidence inculpating him with incendiarism, yet the underwriters refused to insure a second mill which was rebuilt on the ruins of the first. Fifteen years later the proprietor of the mill was awakened in the middle of the night by a message from a priest who was receiving the confession of the watchman, now on his deathbed, and related to the priest that he had accidentally set the mill on fire by breaking his lantern against a machine. Fearing that he would be put in prison for the act, he had disclaimed all knowledge respecting the origin of the fire. At a later day, learning how suspicion had adverted to his employer, he dared not state the truth, although the crime had haunted his conscience for all those years. The priest refused to administer the rites of the church until the watchman's confession had been repeated to the proprietor.

Water is generally referred to as the ideal antagonist of fire, and yet there are many instances where water has caused fires, as in the case of a mill in Rhode Island, where the supply of water to an overshot wheel was regulated by an immense gate, called a leather apron, used in former days for that type of water wheel. During the night a sudden storm raised the water in the river, and imposed an unusual pressure against the leather apron, which had become old and unsound, broke it, let a flood upon the water wheel, revolving it with unusual velocity, and ignited the mill in several places on account of the friction of the hot bearings. Another instance was that of a Connecticut mill, where the flood raised the river to a sufficient height to cover the first floor of a machine shop to the depth of about two feet. The water rose very rapidly, and there being a large amount of iron turnings commingled with wood chips on the floor of the machine shop, the iron turnings oxidized so rapidly that the heat of the process ignited the wood and started a fire which cost the underwriters $30,000.

Fires produced by the action of water upon lime are so frequent as not to require especial notice in this reference to fires outside of the expected and well known causes.

Streams from hose used in extinguishing fires would not ordinarily be classed among the causes of fire, yet such results have occurred in at least two instances. In the one, a stream upon a small fire also met some lime in a neighboring building, starting a fire which did not attract attention until it reached an extent threatening serious results. The other instance was in a large store in Philadelphia, where the stream of water, charged with carbonic acid gas discharged from an extincteur upon a small fire, also served as an electric conductor, and started another fire from the arc lighting system.

The oxidation of iron turnings is quite frequently the cause of mysterious fires, igniting sheds used for storing scrap around iron working establishments. There have been numerous fires in the roofs of foundries caused by explosions of melted iron thrown violently against the roof when by any mishap the iron came in contact with water.

The foundations for a light building upon a very yielding soil were arranged by placing posts down in tubs of iron turnings set in the earth in proper situations, and then pouring over the iron a solution of salt in water. The iron turnings rusted into a solid mass, but the process was carried on so quickly that the heat of oxidation charred the lower ends of the posts, holding them firmly, and also served as an antiseptic treatment, diminishing the liability to decay.

The combustibility of iron is quite noticeable in tack factories, where the tacks are polished by attrition against each other on revolving cylinders, and the fine comminuted dust is so easily combustible that it has served as the source of several fires that were started from some slight accident like dropping a match or exposure to the open light.

Certain forms of fireworks, known as parlor fireworks, obtain some of their most beautiful effects from the combustion of fine iron. The sun, on the other hand, also serves its purpose as a factor of insurance. For its rays have been time and again concentrated upon combustible matter by bull's eyes in such a form that they crudely acted as a double convex lens when placed over doors. It is also a frequent incident in physical laboratories that large double convex lenses are left in such position that the sun will reach them in time and start fires. In fact, as a protection against such accidents, these lenses should always be covered with a cloth bag when not in use. Dishes of tinned iron for domestic use have also concentrated the rays of the sun, as any concave mirror might, upon combustible matter; and it is a well known fact that two considerable fires in America, one at Lynn and the other at Sheboygan, were both caused in this manner by the tin dishes in the window of an ironmonger's shop.

There are other fires caused by peculiar circumstances, comparable to that of the "arrow shot at random reaching the joint of the armor;" as, for instance, a hotel keeper at Biddeford was so rejoiced at the election of President Cleveland that he set off a number of fireworks in front of his hostelry in honor of the event. A rocket shot up into the air and descended in a vertical direction into the dust chimney of a cotton mill in the vicinity. Reaching the bottom of the shaft, it exploded, igniting the dust room and starting a serious fire. Sparks are sometimes the cause of fires as a result of the most unexpected circumstances. In an establishment making table knives, a milling machine which finished the outside of the knife handles was cleared of dust by a large tube projecting down from the room above and connected to an exhaustive blower in the attic. An emery wheel which had been in the same position for a number of years, situated about 20 ft. from this milling machine, struck a spark against a window; thence glancing back, it rebounded some 20 ft., igniting the dust in the lower part of this tube. The flame was carried by the blower to the room above and through a hole in the roof, causing a destructive fire which was not known to the occupants of the room until an alarm had been given by those who had seen it from the outside of the building.

In another instance, a spark from an emery wheel struck the window in front of the wheel. This, glancing back to the belt, rebounded again, and entered a crack between the upper part of the window frame and the masonry of the building and ignited the impalpable dust situated there—an accident which never occurred before, although that machine had been in the same position subject to daily use for over twenty years. Although sparks from grinding wheels frequently ignite combustible matter, yet it is a very difficult thing to do the same thing designedly, even by holding fine matter, as cotton card waste, in a line of the sparks as they are thrown off from the wheel. There have been numerous fires in cotton mills caused by sparks from the dull axes used in chopping hoops of cotton bales, and yet it would be considered an impossibility if one were to take the task of setting the cotton on fire in this manner. A carpenter, while nailing a board to the ceiling in a picker room of a jute mill, struck a nail on one side so that it glanced across the room, entering the feeding apron of a jute picker, and struck a spark which ignited the stock, passing through the picker, and thence spreading to a very severe fire.

The capability of steam pipes to set fire to wood will doubtless continue to be a moot question in the face of conclusive evidence to the contrary, merely because such fires cannot be produced at will.

A few years ago a steam pipe covering composed of wood pulp and ground wool waste was extensively introduced into American markets, with the result of being ignited quite frequently by hot steam pipes. There have been a few instances of the ignition of hair felt used for such non-conductors; in the course of investigation upon some fires of that class, it was found that while the hair felt was not combustible at ordinary temperatures, yet when it had been warmed to higher temperatures it was quite readily combustible. Fires are of frequent occurrence in drying rooms heated by steam pipes for seasoning small bits of lumber used in the decorative portions of cabinet work, under circumstances which do not permit any hypothesis of spontaneous combustion, because the wood at that time has not received any treatment from oils or varnishes.

A mill in Providence, R. I., was burned by a fire originating from the steam pipes in an unlooked for manner. At the time of its construction the proprietor exercised great care that all pipes should be free from direct contact with the wood work; but when the steam was let into the pipes, the expansion increased their length and pushed their end against the wood partition, which was eventually set on fire. Although the fact of fires originating from steam pipes is well established, there is still some obscurity as to the exact subjects which produce such combustion. It is well known that the ignition point of charcoal bears a certain ratio to the temperature of carbonization; the lower the temperature the more readily combustible the charcoal, and this fact is made use of in producing charcoal for the manufacture of some grades of gunpowder by means of superheated steam. Yet applying the data which have been published upon the subject, it will be readily seen that the ignition point of charcoal produced at even the temperature of boiling water is in excess of the heat of steam at the highest working pressure; and yet there are instances of fires produced by steam heating pipes at pressures as low as 10 lb., and also from the heat from the keirs containing hot water used in bleaching.

It seems probable, however, that the charcoal which is ignited under these conditions is not that charcoal which has been carbonized by direct contact with steam pipes, but rather that which has been carbonized by radiation from steam pipies, and therefore at a materially lower temperature than that of the pipe, and then by some changes this charcoal is brought into absolute contact with the steam pipes. Fires from spontaneous ignition of oily waste are so alarmingly prevalent that, as such, an allusion to them has no place in a list of peculiar fires. The introduction of mineral oils for lubrication has tended to reduce this class of fires materially, as the paraffin oils will not oxidize at ordinary temperature, and when commingled with animal or vegetable oils in proportions varying from one-third to one-half, it will also prevent such oxidations of the other oils contained in the mixture.

A watchman in the locomotive works in Boston was very much alarmed when, one evening, the safety valve of the boiler, which was used only for heating in the winter, began to blow off; and he learned that there was a dangerous pressure of steam in the boiler and a fierce fire upon the grates. After the fire was dulled by a stream of water, the matter was investigated, and it was found that the furnace under the boiler had been a receptacle for a lot of small bits of wood in the cleaning up of the boiler room which followed a spasm of order on the part of the boiler tenders; then later, some other person threw some oily waste matter into the furnace door as the best method of getting rid of a dangerous article. A beetle flying into a mill at night became caught in a bit of sliver and straightway flying into the gas jet, dropped and started a fire among the contents of the card room. In another instance, a can of cotton sliver in a cotton mill was found to be on fire, and investigation afterward revealed the fact that the can was in contact with the belt over the pulley, and the friction of the belt on the outside of the can produced enough heat to ignite the cotton. There are records of several similar instances. The blow-off pipe of a boiler burst, causing a back draught, and the flame coming out of the doors of the boiler furnace set the roof on fire.

On the Pennsylvania Railroad an exhaust blast tube of a locomotive turned around, so that it blew a blast in the reverse direction into the furnace of the boiler, and the flames bursting out of the furnace door set the cab on fire, driving the engineer and fireman from their post to a refuge in the water tank of the tender. The engineer, under circumstances of great bravery, came out and reversed the engine, saving the train from a total wreck, although he paid his life as a forfeit for his bravery.

One of the most peculiar fires resulting from a sequence of unhappy circumstances was that of a storehouse connected with a mill in Vermont. Oil is transported on American railways in tank cars in which a cylindrical tank about 5 ft. in diameter and 25 ft. in length is secured upon a platform car. One of these cars was standing upon the siding of a railway near the storehouse, when one of the rear cars of a freight train passing by on the main track jumped the switch at the siding. Numerous persons had observed that this rear car had a hot bearing, which had already ignited the oil on the journal, and as it tore away from the train and plunged down into the oil car, breaking the iron tank, the flames from the hot bearing ignited the oil running out from the broken tank on to the ground, and surrounding the storehouse, burned it down.

THE METEOROLOGICAL OBSERVATORY OF MOUNT VENTOUX.

As the Meteorological Observatory of Mount Ventoux, in spite of its isolation and the difficulty of reaching it, is now a very important station, at which the study of certain questions of electricity is pursued with care, it has seemed to us that it would prove of interest to describe its peculiar position and its resources in electrical apparatus.

We shall first examine its exceptional situation. Mount Ventoux is entirely isolated (Fig. 1). It rises to a height of about 6,000 feet, not by degrees, but abruptly, and overlooks the plains that surround it. Upon its summit, which is of pyramidal form, is situated the observatory, which is reached from the south

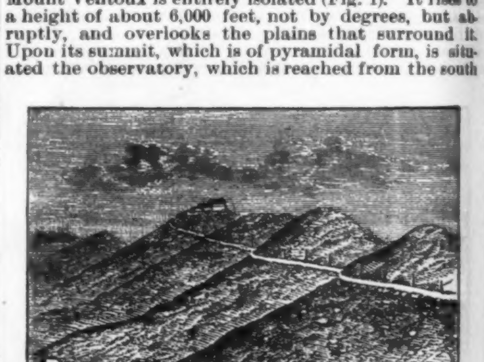


FIG. 1.

through a thirteen mile road that winds its way from the village of Bedoin. It is very difficult of access from the north on account of the steepness. The northerly side of the terrace, where the meteorological apparatus are located, overhangs a precipice hundreds of feet in depth. From this point the view extends over the valley of the Rhine, the Vercors, and Mount Pelroux, behind which rise the highest summits of the great Alps; and, on another hand, over the lower course of the Durance, Provence, and the Mediterranean.

The principal building (Fig. 2) comprises a ground floor, at present unused, and one story above, set apart for the dwelling of the superintendent, the registering apparatus, the archives and fuel, and provisions. The five-foot thick walls rise from a foundation laid in a deep trench. The northern declivity of the summit, left intact, forms a protecting talus analogous to the glacis of a rampart. During the winter the building, which is 98 feet in length, is entirely covered with glazed frost. Every gutter is covered with stalactites of ice, and stalagmites several feet long bar the doors and windows. The observatory then looks like a colossal diamond.

Above the central building there is a semicircular terrace (Fig. 3) that supports the principal instruments. In ordinary weather this is reached by a stairway, but during the prevalence of violent winds, the observer visits the apparatus through a vaulted gallery that runs directly to the terrace.

Owing to lack of funds (for the observatory is kept up by private subscription), the building contains but three utilizable rooms. Two are reserved for the observers and the other is used as a telegraph office, and contains the registering apparatus that communicate, mechanically or electrically, with the apparatus placed upon the terrace.

To the north of the building, upon the semicircular terrace that overlooks the station, are arranged, in the order shown in the plan (Fig. 4), a sort of cabin, closed on three sides and containing a Richard registering

thermometer, a psychrometer, a Piche evaporometer, some ozonometric paper, and maximum and minimum thermometers; a metallic frame provided with Melsens aigrettes and a second evaporometer; an iron support provided with Melsens aigrettes and an actinometer; a large weathercock, with a multiple pointed lightning rod; a pluviometer of the Scientific Associa-

FIG. 2.

tion; a Tonnelot pluviometer; an Alvergniat pluviometer; and a metallic cage containing an anemometrograph and a weathercock.

Besides, upon the central building, there is a rain collector, the water from which enters the cylinder of a Redier pluviograph located in the instrument room. This latter contains telegraphic apparatus of the Morse type, to which is added a rhe-electrometer (that we shall speak of further along), the Redier pluviograph, an apparatus for registering the velocity and direction of the wind, a Fortin barometer, a Redier registering barometer, a holosteric barometer, and a Saussure hygrometer.

Observations are made at intervals of three hours. A supplementary observation is made at half-past twelve in the morning. This is transmitted from Paris to Washington.

Most of the instruments employed at this station are so well known, and have so little to do with electricity,

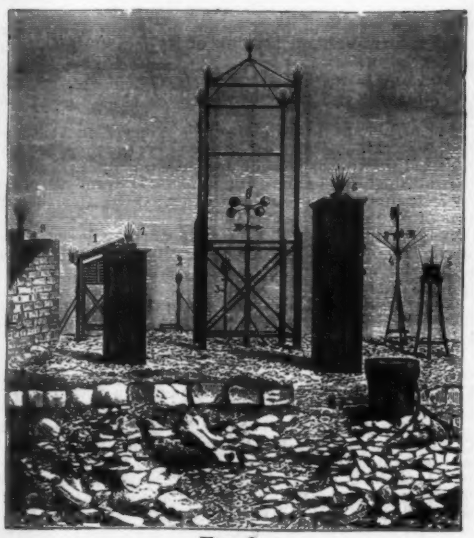


FIG. 3.

that we shall not speak of them. Only four of them belong to the domain of electricity: the ozonoscopic paper, the registering anemometrograph, the rhe-electrometer, and the magnificent series of Melsens lightning protectors, which protect not only the observatory, but also the summit of the mountain.

The Ozonometer.—As well known, oxygen submitted to the action of electricity acquires very strong oxidizing properties. Among the reactions that it is capable of producing, meteorology has utilized the following: Ozone decomposes iodide of potassium and sets the iodine free. If, then, starched paper, impregnated with iodide of potassium, be placed in an atmosphere of ozone, the iodine will be set free and color the starch blue, thus showing the presence of ozone. At the Ventoux station, as at others, there is, under tabular form, a gamut of colors, ranging from the palest to the darkest blue, that serves as an ozonometric scale and permits of approximately estimating the quantity of ozone, according to the depth of color.

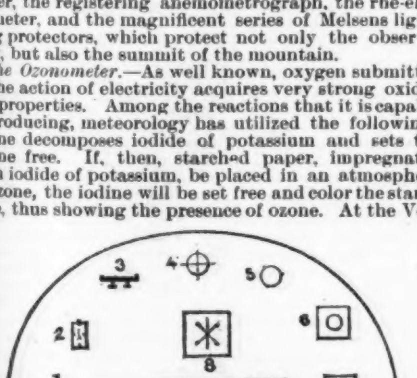


FIG. 4.—THE OBSERVATORY TERRACE.

G. Covered gallery. 1. Shed. 2. Maximum and minimum thermometer, and evaporator. 3. Actinometer. 4. Weathercock. 5. Pluviograph. 6. Pluviometer. 7. Pluviometer. 8. Anemometer and weathercock.

The Rhe-electrometer.—In 1833, Marianini, in studying the currents of batteries, conceived the idea of measuring their intensity by the magnetization that they produced in iron, and of estimating such magnetization by the deflections that it produced on a magnetized needle.

Later on, in order to take out the wire and change it at will, he conceived the idea of winding insulated wire upon a glass tube, and of placing within the latter an iron rod that could be freed from remanent magnetism after every experiment, by warming it and letting it cool slowly.

Fig. 5 shows this arrangement of the rhe-electrometer. S is the solenoid traversed by the discharges or currents of batteries. It can be removed from its support and placed upon another one nearer the needle.

FIG. 5.

F is a bundle of iron wires. In certain models the needle was suspended by a cocoon thread instead of being pivoted.

Marianini showed that his rhe-electrometer could be used as a means of detecting the direction of lightning. To this effect, said he, I propose to connect two not very approximate points of a lightning rod with the extremities of the wire of the bobbin of a rhe-electrometer. Every time the lightning passes through the rod, a portion of the electricity will magnetize the wires, and the deflection of the needle will indicate the direction of the magnetization; in other words, will make known whether the lightning ascended or descended the rod.

Melsens took up and developed Marianini's experiments, and gave the instrument its present form (Fig. 6). At the bottom of a box four inches in diameter there is a bobbin, B, within which are placed rods, A A, of iron or steel, destitute of magnetism. At L and T are two terminals to which are affixed the extremities of the wire of the bobbin, B. Above this latter, at right angles, is placed a magnetized needle that passes over a graduated dial. To employ the apparatus, the terminal, L, is connected with the lightning rod and T with the earth. The direction of the deflections permits of knowing whether the lightning proceeds from the earth or the clouds.

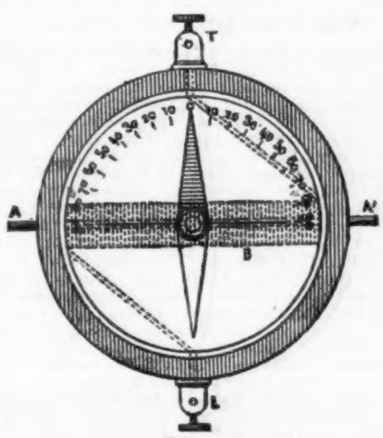


FIG. 6.

FIG. 7.

The Melsens Lightning Protectors.—At all the angles of the central building, of the covered gallery, of the metallic housings, and of the iron supports on the terrace, there are aigrettes of varied dimensions, some short and mounted on brackets (Fig. 7) and others fully a yard in length. All these are connected by metal, not by a single rod, but by wires $\frac{1}{12}$ of an inch in diameter, running from one apparatus to another, and supported by a series of poles, between which are placed cast iron pipes.

The summit of Ventoux, formerly the scene of storms and frequently enveloped in lightning, has, since the installation of the Melsens apparatus, been protected against all discharges, and has never been struck.

The great expense incurred in making a suitable roadway, in establishing a telegraph line, etc., have exhausted the funds that were generously subscribed by the public. The instruments rendered incorrect, or broken, or carried away by tempests, will have to be replaced; the buildings have suffered much; and, despite his devotion, the observer, who has many times had his hands frozen, was forced last winter to abandon his post, which had become absolutely uninhabitable.

But it is permissible to hope that the work so brilliantly begun will be finished, and that when it is connected by telegraph, and put in constant relations with the other great meteorological stations, the Ventoux Observatory will take the important rank among them that it deserves to occupy.—*Abridged from La Lumiere Electrique.*

GLACIAL EPOCHS AND THEIR PERIODICITY.

By ADOLPHE D'ASSIER.

WHEN Agassiz announced for the first time that, at a far off and unknown epoch, the valleys of the Alps had disappeared under an immense mantle of ice, nothing was seen in this phenomenon but an inexplicable event without precedent in the annals of the planet. An attentive study of the deposits left by the glaciers soon demonstrated that at the beginning of quaternary times the North of Europe and North America had been the scene of two glacial epochs separated by a long interval, and that the deposits left by the second were inferior in extent to those of the first. Later on, there were found, at various points, traces of a third glacial action, posterior to the second and much less marked. The advent of great circumpolar winters was therefore a periodical phenomenon; but what cause was to be invoked, and what duration was to be assigned to them? Seeing that they were powerless to find the key of the enigma in the laws of meteorology, geologists turned their attention to the disturbances that the celestial bodies of our system cause in the annual travel of the earth around the sun. These disturbances—such as the variations in eccentricity of the great axis, the precession of the equinoxes, the shifting of the perihelion, cosmic clouds, etc.—being of diverse order, it remained to select and lay hands upon that astronomical cycle which best agreed with the indications drawn from a study of the ancient glaciers. A half century of researches and controversies has elucidated the majority of the obscure points, and, although a few skeptics, whose wise reserve cannot be blamed, still hesitate, we think that the proposition may be advanced that at the present hour the solution of the problem is about reached. I am going to set forth, as briefly as possible, the considerations that tend to establish the fact that the progressive cooling of the planet must necessarily, in the course of ages, have brought about the apparition of circumpolar glaciers, and that the periodical and alternate return of these in the two hemispheres is closely connected with the secular displacement of the perihelion. This view, moreover, has the advantage of presenting itself as the simplest and most rational one, and the one that least favors objection.

Let us suppose that the earth described a circle around the sun. Then we should know neither the torrid heat of summer nor the rigors of winter. A perpetual spring would reign over the entire surface of the planet, and a uniform meteorology would but insensibly modify the terrestrial relief. The organic kingdom, never being trammeled in its flight, would reach the two poles. Sure of the morrow, the human race, in the normal course of its destiny, would experience neither exhaustion nor periods of arrest. Unfortunately, the elliptical nature of the tellurian axis and the laws of celestial mechanics have not countenanced such Edenic perspectives since the time that the terrestrial surface, completely cooled, began to be heated only by contact with the sun's rays. I mean since the dawn of quaternary times. A long and vigorous winter prevailed alternately over each hemisphere every twenty-one thousand years. The immense cap of *neve* which extended from the pole to temperate latitudes profoundly modified the relief of the earth in consequence of the erosive action exerted by glaciers upon the sides of mountains and in the valleys. Plants and animals, receding before the terrible enemy, fled toward the tropics.

This hegira of the living world, carrying along man, each time shifted the axis of civilization. The causes that bring about glacial phenomena are various. Some depend upon astronomy and others upon meteorology. The first, and most important, is the obliquity of the ecliptic, that is to say, the angle made by the axis of the earth with the perpendicular to the plane of the orbit. This angle varies between 34° 35′ 38″ and 21° 58′ 38″, and is now 23° 27′ 50″. The immediate effect of such inclination is to expose each pole alternately to an insolation of six months and to a night of the same length of time. The great depression in temperature caused by so long a night is revealed by an immense stratum of circumpolar ice, which the uninterrupted action of the sun's rays during the succeeding months can make recede, but cannot make entirely disappear. It is a glacial period of half a year, circumscribed over a space of relatively small extent, which increases or decreases according as the inclination of the world's axis approaches or recedes from its maximum amplitude.

A movement of the plane of the ecliptic, known as the displacement of the perihelion, raises the period from six months to ten thousand five hundred years, and gives Titanic proportions to the extension of the glaciers. In consequence of the attractive influences exerted upon our globe by the other planets of our system, especially Venus and Jupiter (whose action is preponderant, by reason of the proximity of the one and the mass of the other), the longer axis of the terrestrial

orbit shifts slowly from west to east, so as to describe an entire circumference in twenty-one thousand years. In this interval the seasons undergo modifications that invert the climate. When the perihelion passes to the winter solstice, the long axis then coinciding with the solstitial line, the total duration of the spring and summer of the boreal hemisphere exceeds that of the autumn and winter by several days. The contrary occurs in the austral hemisphere, where the seasons are the opposite of our own. Autumn and winter combined exceed the spring and summer in duration. This prolongation of the cold season in the antarctic regions which follows the variations in eccentricity of the earth's orbit, and is now nearly eight days, connected with the circumstance that the sum of the hours of the nights (that is to say, of the cooling) is much greater than that of the hours of daily insolation, necessarily favors falls of snow and the formation of ice.

An immense winding sheet of snow, capable at the time of its maximum extension of reaching beyond the 40th parallel, covers the circumpolar regions of the south, which thus become the seat of a glacial cycle. In measure as the perihelion, attendant upon the motion of the great axis (of which it occupies one of the extremities), approaches the vernal equinox, the interval that exists between the cold and warm seasons, tending to disappear, the antarctic ice recedes toward the south pole, while that of the north pole begins to make its way toward temperate latitudes. Finally, when the perihelion reaches the summer solstice, which it does ten thousand five hundred years after starting from the winter solstice, the climates are completely reversed. A great circumpolar winter prevails over the boreal world, while the austral regions see the ancient glaciers disappearing or receding. They will not resume their former extension until after a new interval of ten thousand five hundred years, thus raising the periodical return of glacial action in each half of the globe to twenty-one thousand years.

A third factor modifies this action in each case, now by increasing and now by decreasing its intensity. I speak of the variations that the eccentricity of the terrestrial orbit undergoes under the disturbing influence of the planets. We know from the calculations of Laplace this element of celestial mechanics, viz., that the distance that separates the foci from the center of the ellipse that the earth annually describes around the sun alternately elongates and diminishes during thousands of centuries. The difference in length between the cold and warm seasons, increasing or diminishing at the same time that such distance does, it follows that the glaciers in the first case will reach an extension that they will lose in the second. In studying the great period of the Alps, we shall soon see a striking example of this law.

Meteorology, too, furnishes on its part factors in the complex problem of glacial epochs. The first, and most important, is the evaporation of the seas. As has been so judiciously observed by Tyndall, it is the vapors of the ocean, especially those of the equatorial regions, that, driven by the wind, continuously feed the *neves* of the circumpolar regions. Let evaporation cease, and immediately there will be no more clouds, no more rain, no more snow, no more glaciers. The great falls of water that characterize the glacial epochs are in nowise, as is sometimes stated, a temporary and local exaggeration of atmospheric precipitations. They exhibit themselves, on the contrary, as a permanent geological phenomenon that can be followed from age to age from the first geological times to our day, and at the present hour we find it in the tropics, where it has lost nothing of its energy of yore. It is, in fact, the diluvian rains of the primary, secondary and tertiary that have caused the formation of the layers of sediment of the terrestrial rust. During the deposit of the quaternary, they gave rise to the ancient glaciers, as well as to the vast watercourses of that epoch, and they still continued under the Pharaohs, as is proved by the nilometer graven upon the rocks at the cataract of Syene, and according to which the great freshets of the river exceeded by thirty feet the level of those of to-day. In our day, these rains are seen following the apparent motion of the sun toward the tropics continuously, and producing annual overflows of the rivers of the torrid zone. As the evaporation of the seas diminishes in the course of ages, as a consequence of the cooling of the sun and the earth's surface, which permits the ocean to infilter into the earth's pores and thus to limit the surface of evaporation, we have the right to conclude therefrom that the ancient glaciers reached greater dimensions than those of the present era. We shall soon see that this view is confirmed by observation.

The orientation of mountain chains with respect to the winds that carry the ocean vapors is likewise a capital element of glacial action. In fact, it is not necessary to have recourse to great depressions of temperature to explain the apparition of *neves* and ice. It only requires a mountainous country placed under the influence of cold and humid winds that bring on frequent precipitations of snow. According to Charles Martin, a diminution of 4° or 5° in the present thermic state of the Alps would bring back the ancient glaciers of Switzerland. The flora of the diluvian, moreover, indicates a moist and temperate climate. New Zealand offers us a striking example of the influence that the orientation of mountain chains exerts upon precipitations of snow. According to Haast, as the western side of the island receives four times as much vapor as the eastern, the glaciers descend there to 650 feet above the level of the ocean, amid a rich tropical vegetation, while on the east side, where the plane is less steep, they generally stop at an altitude of 3,200 feet, and rarely reach 2,500. The same phenomenon is reproduced in a still more marked manner on the Himalayas. As the side exposed to the south receives more vapor than the opposite one, the snow descends much lower on it, while the difference in temperature between the two sides might make it supposed that the contrary would be the case.

Finally, as a last factor in glacial action, let us mention the altitude of mountains. The more elevated a peak is, the more it favors the fall of snow, and consequently the extension of glaciers. As the height of mountains diminishes from century to century, under the erosive action of meteorological agents, such as lightning, frost, storms, and winds, which disintegrate the summits and carry the debris into the plain, it results that in every mountainous country the extent of the glaciers is so much the less in proportion as they belong to a more recent epoch.

Upon the whole, the periodical return of great circumpolar winters has for a starting point the cooling of the earth and sun, and depends besides upon the simultaneous action of half a dozen agents, which, nearly all of them variable, modify each time the potency and extent of the glacial phenomena. The three first, borrowed from astronomy, are the inclination of the axis of the poles, the displacement of the perihelion, and the variations in eccentricity of the terrestrial orbit. The three last, drawn from meteorology, are the evaporation of the seas, the orientation of mountain chains with respect to humid winds, and the altitude of peaks.

These premises laid down, let us endeavor to determine the geological epoch at which the passage of the perihelion to the summer solstice coincided with a cooling of the planet sufficiently marked to bring upon the boreal hemisphere the first great circumpolar winter. It could not have been previous to the pliocene, because the rich fossil miocene flora of Greenland and Spitzbergen and of other arctic lands demonstrates that at this time the ice of the poles, if it already existed, had little thickness and area. After the definitive lifting of the principal chain of the Alps, Andes, and Himalayas, that is to say, in the pliocene period, falls of snow must have occurred upon the sides of the high summits; but the glaciers that resulted therefrom were local and, so to speak, accidental, like those that we observe in our day on the counterparts of the Cordillera in equatorial America. It was at the beginning of the present era that the depression of the temperature was sufficiently pronounced upon the surface of the earth to allow the displacement of the perihelion to bring about a glacial epoch in the north of Europe, of America and of Asia. It was, in fact, at the moment when the quaternary age was opening, that was deposited that formation characteristic of the glaciers—the diluvium, so called because it was at first attributed to the deluge mentioned in Genesis. It is only in recent years that its true nature has been recognized, although Schimper, at the end of the last century, and Charpentier, at the beginning of the present, announced the glacial origin of the diluvium of the Alps, where this deposit is well developed. The revelations of these two geologists passed unnoticed, so much were they in contradiction with the ideas of that time.

Agassiz was met with the same indifference in 1837, when he announced to the congress of Swiss naturalists assembled at Neufchatel the existence of an ancient glacial epoch. All the members of the assembly were consternated. Leopold De Buch, unable to believe his ears, lifted his hands toward the heavens and invoked the manes of De Saussure. It was not till 1840, after the publication of his work upon the glaciers of the Alps, that he attracted the attention of a few geologists, among them Lyell. The latter, having gone to Switzerland, verified for himself Agassiz's observations, recognized the correctness of his views, and rallied other naturalists to his cause, especially those of Great Britain, who soon found traces of glacial action in the mountains of England and Scotland.

To-day, the periodicity of glacial epochs has taken a rank in science, and it is to be presumed that it has found its definitive formula. There no longer remains anything but a few points to be elucidated.

(*To be continued.*)

THE INTELLIGENCE OF FISH.

A GILLING net had been placed across the outlet of a small tributary of Popihacka Creek. In this little spring brook several large pike had wandered in search of minnows. Being disturbed, they rushed with great impetuosity toward the net, and the foremost of them was at once securely entangled in its meshes. Straightway the others stopped as suddenly as they had started and, recognizing their fellow in trouble, "took in the situation" at once. Each pike evidently realized the true condition of affairs, and reasoned thus: That pike tried to go through this obstacle in the water, and is in trouble; it is necessary for me to avoid it by some other means. There were five of these fish that paused close to the net; and each acted, I believe, as it *thought* best. One of them came to the surface, and, after a moment's pause, turned upon one side, and leaped over the cork line. Seeing the success of this effort on the part of one, a second did the same. A third came to the shore near where I stood, and, discovering a narrow space between the brail and the net, passed very slowly through, as though feeling its way, although the water was so shallow that its body was fully one-third out of the water as it did so. The others were either more timid or less cunning. They turned to go up stream; but being met by my companion, who was making a great noise by whipping the water, they rushed again toward the net, but checked their course when their noses touched the fatal net. Prompt action was necessary. They had not confidence in their leaping powers; and both, as though struck with the same thought at the same moment, sank suddenly to the bottom of the stream, and burrowed into the sand and beneath the lead line, which was in full view. In a moment they reappeared on the other side of the net, and were gone. I could have prevented the escape of all these fish, but was so much interested in the evidence of thought exhibited by them, that the idea of molesting them did not occur to me. There was something in the manner of these fish, too, which is not readily described, but which give an importance to those acts, on their part, that I have mentioned, and which added materially to the strength of the evidence that they were "thinking" in all that they did.

After years of familiarity with the many species of fish found in the Delaware River and its tributaries, I find that they can only be intelligibly described by using such terms as "cunning," "fear," "grief," "ingenuity," and "anger;" and if tneir actions unquestionably indicate the possession of such emotions and faculties —and I claim that they do—then the great gulf, mentioned by Mr. Romanes, between the intelligence of fish and that of ants and bees is materially lessened; and future studies of the much-neglected subject of the habits of fish will, I believe, ultimately show that many fish are the intellectual equals of any existing insects.—*Chas. C. Abbott, M.D., the Swiss Cross.*

THE AGE OF THE STARS.*

II.

GENTLEMEN, it was the invention of the telescope that gave the doctrine of evolution the basis indispensable to cause it to leave the earth and enter the solar system. It was the use of telescopes that allowed Herschel to apply it to the world of nebulæ. It will now be spectrum analysis that will take charge of the stars.

In fact, the problem as to the stars is an extremely difficult one. The stars are simple brilliant points. The most powerful telescopes show us still other stars beyond. And even the more perfect the telescope is, the smaller the point must be. This point is surrounded with luminous rings and is often affected by phenomena of scintillation.

The rings are due to the form of the luminous motion itself, and scintillation is due to our atmosphere. In all this there is nothing that regards the image itself save to disfigure it. The telescope, therefore, is not an instrument for such research. We must select another method—that in which we separate the elementary rays proceeding from the star studied. Instead of studying the light from the standpoint of the images that it may give us, we analyze it, and the analysis reveals to us the chemical nature of the body that sends the light, and even of those which, situated in the line of the rays, may modify them through absorption.

I need not, gentlemen, repeat the history of the discovery and first applications of spectrum analysis, it has been so often done that it is unnecessary to dwell upon it. You still recall what a sensation was produced on the public by the announcement that a chemical analysis of the solar atmosphere had just been made, and that the presence of most of our terrestrial metals had been detected in it. You know how such analysis soon extended to the stars and nebulæ, and how science was then capable, through testimony of sublime power, of affirming the material unity of the universe. The material unity of the universe—what a conquest for science! what a veil lifted before philosophers, savants and thinkers, and showing them a world open to their labors and meditations!

For our part, gentlemen, who are following the progress of the idea of evolution in history, we must say that the discovery of the chemical unity of the universe gives it the firmest base that it has ever received. In fact, since the earth has been a globe of fire, since it has already traversed a number of periods before reaching its present state, and all these phenomena find their cause in its cooling, what a deduction it is to admit that the sun, formed of the same elements as the earth, must, too, surely undergo a like evolution and similar phases, although, on account of its greater bulk, with greater slowness.

And now how could the stars, formed of like elements (varying only in their combinations), escape this great law?

Let us here add that Herschel's conception that the non-resolvable nebulæ are formed of cosmic matter, and not of stars whose distance prevents us from separating, is confirmed in a brilliant manner by the analysis made by Huggins, who states that they exhibit the characters of incandescent gases.

It is justifiable, then, to use the word evolution when we speak of the stars. It is justifiable, too, then, to apply the word *age* to them, this being only a consequence of the first.

Such, gentlemen, as a whole, are the discoveries that have led to the introduction of the doctrine of evolution into astronomical science.

Let us now examine upon what basis science rests in order to get at the relative ages of the stars. It is through a consideration of the spectrum furnished by these bodies that it proceeds.

We may, in a general way, admit that, when a sun is formed, and all things are equal, moreover, the higher the temperature of the star is, the more efficiently it will perform the functions of radiant stars, and the longer will be the period during which it will be able to fulfill them. It is true that the constitution of these celestial bodies is not yet sufficiently known to allow us to distinguish with certainty the conditions that might chance to disturb these simple and general data. But it is not well to stop at once at such difficulties. The age of the stars, then, is connected with the temperature of their subtance. Now, such temperature is shown by spectral characters.

In fact, gentlemen, that wonderful prismatic image that shows us the collection of rays that a star sends us separated, classified, and ordinated, and in which we now know how to read the chemical composition, motion, and so many other valuable data, instructs us besides as to its temperature. Were the body simply heated without being raised to incandescence, its spectrum would notify us of that fact by the absence of those rays that give us the sensation of light. But as soon as incandescence occurs, the luminous and photographic rays exhibit themselves.

When the incandescence is still more pronounced, the spectrum becomes richer on the violet side, which is always the index of a high temperature. Were the temperature to rise still further, the violet and the rays that follow it would become more abundant. We may even conceive, by a sort of abstraction, of a body raised to such a temperature that it would no longer emit anything but the rays situated beyond the violet (which the eye would no longer perceive), and which would be revealed only by photography, fluorescence, or thermoscopic apparatus. Thus, in the increasing scale of temperatures, the body is at first invisible, then becomes visible, and ceases again to be so, through the very excess of such temperature.

The spectrum faithfully translates all these states, and permits us to read the most delicate circumstances with wonderful fidelity.

A star, then, whose spectrum is very rich in violet rays is one whose external envelopes at least are raised to a high temperature. There are a large number of such stars in the heavens. They are, as a general thing, the ones whose light appears to us white or bluish. The most remarkable one is the magnificent star Sirius, which, by the volume of light that it sends us, is without a peer in the heavens. The size of this star is enormous, and out of comparison with that of our sun. It is surrounded with a vast atmosphere of hydrogen, as is proved by its spectrum. Without any doubt, it contains the other metals, but the presence of these it

* Continued from SUPPLEMENT, No. 630, page 10057.

is difficult to ascertain, because of the power of radiation of its enormous atmosphere, whose effluvia mask the other rays. Everything here indicates a sun in the full power of its activity, and one that will preserve such activity for an immense period of time.

After Sirius, which is the ornament of the heavens, and which, according to the dicta of science, will endure for a long time, we find Wega of the constellation of Lyra as a star surrounded by a vast hydrogenated atmosphere. It is a white star that is often observed at the zenith of our heavens. It is agreed that the mass of this star is raised to a high temperature, and that it has before it a long period of activity and radiation.

These two examples of stars in the full development of their solar activity are, perhaps, the most remarkable, although not the only ones. In the heavens, there is a large number of stars belonging to this class. Let us even say that the largest number of stars visible to the naked eye are in this category. But, at the same time, another class of stars has been discovered in which the characters of the spectra indicate a much more advanced stage of condensation. Instead of vast atmospheres of hydrogen, analysis shows a gaseous, low, dense stratum formed of those metallic vapors that we find in our own sun, for our central orb belongs to that class of stars whose solar functions seem still powerful, but which nevertheless have got beyond what may be called *youth*, if the expression is allowable. What is remarkable is that the color of these stars is, as a general thing, in harmony with their constitution. They have not that brilliancy, that whiteness, that characterizes the stars of the first class. Some are of a yellow, and even of an orange color.

As an example of those stars that have got beyond the most active period of their radiation, let us cite our sun, which no longer belongs to the first class; then Aldebaran, or the Bull's Eye, which is on the sun's route, and which shines in winter over the constellation of Orion; Arcturus, the beautiful star of Bootes, and which is situated in the prolongation of the stars of the tail of the Great Bear, and the red fire of which reveals an already advanced evolution.

But there are likewise stars that have reached a still more advanced degree of sidereal evolution. Here, the spectrum shows most decidedly the signs of a fatal cooling. Violet, that color of high temperatures, fails here almost absolutely. At the same time, dark bands, indices of a thick and cold atmosphere, in which chemical affinities are already beginning their work of association, encroach upon the spectrum. It is a remarkable thing that the color of such stars answers, as a general thing, to conditions of decrepitude. It becomes dark orange and often passes to dark red. The star that corresponds to the upper left angle of the constellation of Orion is in this condition.

Such, gentlemen, are the first results of a study which is only in its beginning. I have tried to present it in its simplicity, and to remove the difficulties and objections that it may legitimately raise in applications to such or such a particular case. I am persuaded that science will triumph over such difficulties, as it has triumphed over still greater ones, and that the general bases of the method will not be prejudiced by them. This method will lead us to lay down definitely that great principle of evolution which is called upon to become one of the most fruitful of astronomical science. Born of the consideration of our terrestrial existences, it seemed that it was never to cross the horizon of our globe; yet it has done so, and is now definitively taking possession of the whole heavens.

In fact, we have seen how, in the first place, by reason of the analogies in constitution, form, and origin recognized between the earth and the planets, thanks to the wonderful instrument that, as it were, annuls distances, it became possible to extend the principle of the igneous origin of our globe, and the successive revolutions that it has undergone, to all the members of the solar system; how a comparative study of those strange masses of nebular matter situated at the most distant extremities of the visible heavens has permitted us to grasp the signs of successive transformations that make us spectators, in imagination, of the formation of suns and the genesis of worlds; how, finally, the spectral method, entering the lists in turn, and attacking the problem by means entirely new, has permitted of a study of each of these suns in particular, and revealed to us the astonishing differences in their constitution, and the qualities and power of their radiation. Some are still in course of formation, and are exhibiting the characters of an incandescence of the immense atmospheres by which they are surrounded, others have already got beyond the period of their greatest activity, others again exhibit the characters of a function that is becoming feeble and of a star that is approaching its decline, and all, through the very diversity of the phases of their evolution and the length of time the latter requires, give us the measure of the immense periods that must have elapsed from the epoch at which the most ancient of these worlds had their origin up to the moment that it is given us to consider them.

When the bases of sidereal evolution shall have been definitely laid down, science will have made one of its most astonishing conquests. Through it, it will be given to man to go back through cosmic ages, and to read in the stars their past and future, as he has already measured their distances, obtained their weight, and analyzed their matter. Then a knowledge of the infinite in time will be added to that of the infinite in space.

It is thus that science is opening wider and wider to human intelligence the mysterious and divine book in which is written the history of the universe. This, man will soon read page by page. He will be spectator of the births of these worlds, of the geneses of these suns, of these splendors, these wanings, and these gigantic cataclysms. He will rise higher still, and will arrive at an understanding of those eternal laws that preside at the mysterious alliance of matter, force, and mind in space and time.

What spectacles for a soul enamored of the sublime; what ecstasy and what rapture! What a testimony to the grandeur and destiny of human intelligence, and, at the same time, what an invitation to a high moral dignity! Here is the true end of science.

Its sole object is not to submit the forces of nature to us, and thereby increase our power and well being; still less does it spring from vain curiosity or sterile pride. No, gentlemen, the thirst for knowledge which is consuming man, and which has cost him so many efforts, sacrifices, and martyrdoms even, since he began to reflect upon nature, has its origin in the mystery of his intellectual and moral destiny. The secret and irresistible instinct that carries us to science is not deceptive. Through the efforts that science demands, through the tastes that it develops, through the spectacles that it offers us, it fortifies the soul, enlarges it, elevates it, ravishes it, and transports it to regions whither nothing unworthy of it can follow. It is through this that it is of origin truly divine, and that it merits all our sacrifices, all our efforts, all our love.—*Revue Scientifique.*

SUN DIALS.

We have been asked several times by some of our readers to give them directions as to the construction of a sun dial. In complying with the request, we shall treat the subject historically, theoretically, and practically.

History.—The need of fixing the division of time

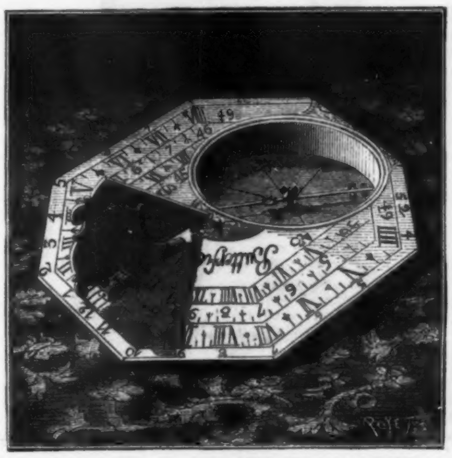


FIG. 1.—SUN DIAL OF THE SEVENTEENTH CENTURY.

graphically must have been felt from the beginning of the world. It is certain that the Egyptians found a way of doing it in the apparent motion of the heavens. No sun dial, however, has been found in the antiquities of Egypt, but it is supposed that the inhabitants of that country observed the length of the shadow of the obelisks that were scattered throughout the land, and that they calculated the hour from that. They likewise used clepsydras. We are certain that the sun dial was known in Judea, since Isaiah (750 B. C.) asserts that God set Achag's dial back. Diogenes Laertius attributes the invention of sun dials to Anaximander, and Pliny gives the honor of it to Anaximenes of Miletus (600 B. C.). Herodotus says that the Greeks received this invention from the Babylonians, and Plutarch asserts that the Egyptians measured the height of the pole with a tablet in the form of a tile, making a sharp angle with the plane of the level, whence we must conclude that the invention of the equinoctial dial belongs to them, because it is a natural consequence of the knowledge of the obliquity of the ecliptic.

The Romans did not know of the sun dial till the time of Cicero, Cæsar, and Cato. Valerius Messala brought one from Catana. This was placed upon the rostrum, but it could not have been accurate, as it was constructed for a latitude less by 4° 30' than that of Rome. The Romans also made use of the gnomon, but this could have been no more correct than obelisks, on account of the penumbra. Moreover, it could indicate the hour approximately only at noon, the moment at which the shadow, being shortest, remains immovable for an instant. For this reason slaves were charged with the duty of making this time known.

To Eratosthenes is attributed the invention of a hollow sphere or hemisphere called a skaphe, and provided with a straight style in the center. The plane in a line with the sun and the style that was held ver-

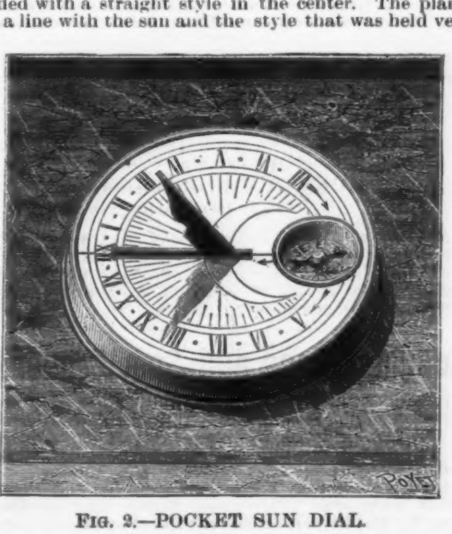


FIG. 2.—POCKET SUN DIAL.

tically intersected the concavity according to a semicircle, which, receiving the projection of the shadow, marked on it the sun's height. From this description it will be seen that this kind of a dial could not have been of very great utility, and that the property of all gnomons resides in the simple process at present employed for finding the meridian of any place, as we shall show further along.

Despite the efforts of so many men of genius (whose names have been preserved in history) to discover a method of fixing a knowledge of the time, the sun dial was not invented till the day on which the shadow of the gnomon was able to lie upon the surface or wall carrying the hours. One of the oldest of this sort of apparatus known comes to us from Phenicia. It is in the form of a hollow ellipsoid, with a horizontal style, and has been reconstructed by the present learned director of the Conservatoire des Arts et Metiers at Paris, where it may be seen.

Since the time of Vitruvius (100 B. C.), and especially since the sixteenth century of our era, the art of tracing sun dials has been enriched with all the data of geometry and mathematics.

To-day, this branch of science—gnomonics—is established in theory upon an infallible basis. The neglect of this valuable object for regulating watches could not be explained did we not know that up to the present the most serious obstacle to the use of it has been the difficulty of finding a system of simple management that will render the use of it convenient and comprehensible to all.

Sun dials, more or less ornamented, have been constructed in all times. In Fig. 1 is shown a curious dial of the seventeenth century. In Fig. 2 is shown a pocket apparatus got up by Mr. Rimbaud. It suffices to orient this little dial with the compass with which it is provided to obtain the hour through the shadow of

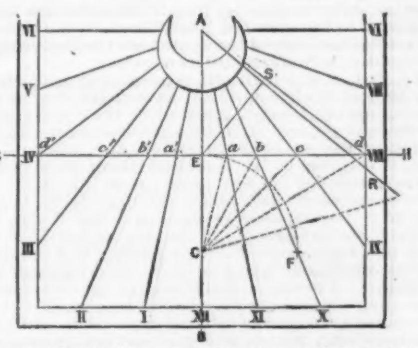


FIG. 3.—METHOD OF MAKING A SUN DIAL.

the style, which latter, after the reading has been done, is made to enter a slot in the face.

Sun dials can be consulted only for the latitude for which they have been constructed, and, as the hour is read in reverse order, according as we are on one or the other hemisphere, it will be seen that in order to know the true hour exactly, by means of these instruments, we should have to have 180 of them. The same is not the case with the equinoctial dial, and especially with the universal solar clock recently invented by Mr. Rimbaud.

Hereafter, we shall give the theory of the sun dial of the equinoctial type, and in the meantime we shall make known the method of laying off simple mural and portable dials.

Draw the line A B (Fig. 3), which will be the central line of the dial. At A make the angle, B A R, equal to the latitude of the place, and prolong A R indefinitely. From any point, S, selected upon A R, draw S E at right angles with A R, and at E draw G E H at right angles with A B. On A B make E C = E S, and from the point, C, as a center describe the quarter circle, E F, which divide into arcs of 15°, in starting from the point E. Through the points of division draw the radii *Ca*, *Cb*, *Cc*, etc., and lay off the distances E*a*, E*b*, E*c*, etc., toward G at E*a'*, E*b'*, E*c'*, etc. From the point A draw the lines A*a*, A*b*, A*c*, etc., A*a'*, A*b'*, A*c'*, etc., which will be the lines of the hours, and inclose the whole in a circle or a square.

The line of 6 o'clock is the perpendicular raised upon A B at A. The hours before 6 in the morning and af-

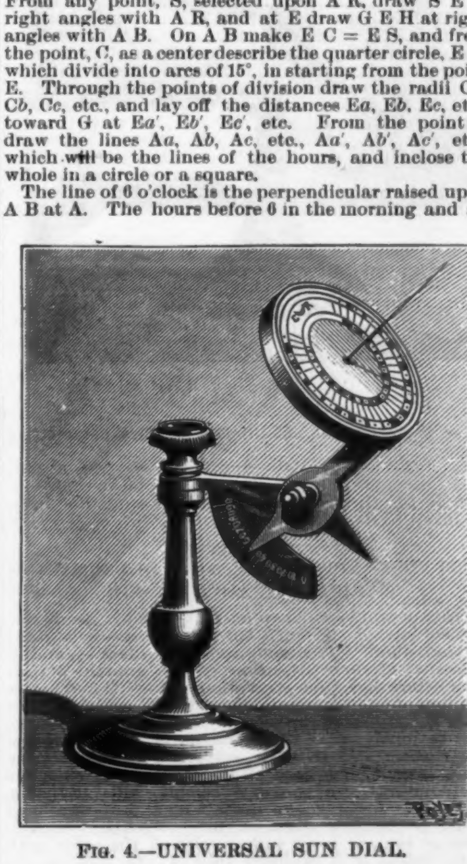


FIG. 4.—UNIVERSAL SUN DIAL.

ter 6 in the afternoon are given by the prolongation of the lines V^h and VII^h beyond A.

The dial is to be placed upon a horizontal surface, and so oriented that the point, A, is directed toward the south. As for the style, that is given by raising in the vertical plane, A B, the triangle, E A S, the upper side, A R, of which may be prolonged to the extent desired.

If the half and quarter hours are desired, it will be

necessary to divide each of the arcs from E to F into two or four parts, thus giving new points on E H.

Theory of Sun Dials.—Let us in imagination divide the globe that we inhabit, remove a section in the plane of its equator, and allow it to retain its ideal axis, which will be our gnomon. From the foot of this axis, at the circumference of our terrestrial disk, let us draw twenty-four radii of equal length, and inscribe one of the hours of the day upon each of them. If no disturbance has taken place in its natural orientation, this band of earth will effect its double rotary and forward motion on the ecliptic. An observer situated externally to it would have before his eyes the equinoctial sun dial, its principle and its theory. For six months, only the traced surface would be illuminated, and in the next six months the hour would be read on the opposite surface, but in inverse order.

Now, in imagination again, let us repeat this object as shown in Fig. 4, and let us put it upon our globe, which we will say has been reconstructed by a miracle. If we desire to make good use of this dial, let us give it the same position that it had when we traced it, that is to say, at every spot on the earth where we chance to be, let us place it in such a way that its southern line shall be parallel with the meridian of the locality, and its plane parallel with the equator. Under such circumstances, its style, at right angles with its surface, will be naturally at right angles with the axis of the world, and its elevated extremity will be directed toward the pole star.

Let us state, in passing, that it will not mark before six o'clock in the morning, nor after six in the evening, and that at the time of the equinoxes, the sun, being at the equator, will illuminate its edge only.

This dial, of which all others are merely projections, may be used in all countries; its construction is very simple, but everybody cannot effect the orientation of it. Several systems have been devised with a view of rendering the use of it convenient, and, among these, there is one due to Mr. Rimbaud which we may mention as a new and interesting invention (Fig. 4).

Universal Solar Clock.—This instrument (Fig. 5) seems to us to be the happiest realization of the theory that we have just explained. In fact, our planet itself is a clock that regulates our civil customs. If we suppose it to be transparent and provided with a material axis, the shadow of the latter will be seen to fall upon the side away from the sun and traverse its equator in twenty-four hours, at the rate of fifteen degrees each. Its slight variations with respect to our clockwork instruments are compensated for at the end of its revolution on its orbit. Moreover, tables are given that permit of establishing the equations of the minutes every day. The apparatus shown in Fig. 5, then, is a faithful image of the earth. Oriented once for all, like our planet, by a system as simple as it is rational, carried along by the earth in its revolution and shifting, it receives, like the

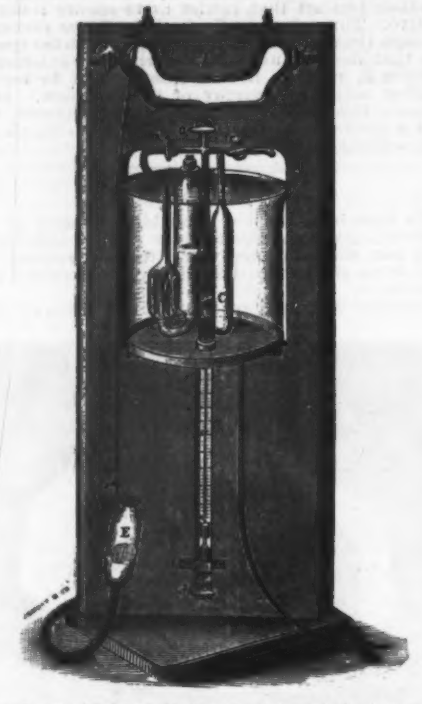
FIG. 5.—UNIVERSAL SOLAR CLOCK.

latter, the central ray of the sun at the same relative points.

Its advantages over the equinoctial dial are that it marks the hour as long as the sun is upon the horizon, even during the equinoxes, and at the same time is an ornament to the garden.—*La Nature.*

PORTABLE APPARATUS FOR DETERMINING CARBON DIOXIDE IN AIR.

THE apparatus is shown in the diagram. An oblong wooden box, not given in the figure, is screwed to the wooden stand. The sample of air enters A, and is measured off here by means of the graduated scale both before and after absorption of the CO_2. The absorption of CO_2 is carried out in B. By raising or lowering E, which contains mercury, the measuring pipette may be filled with either mercury or air. A drop of water is always kept on the surface of the mercury. In adjusting the meniscus of the mercury previous to reading off, the pressure in A is made equal to that in C. A differential gauge containing a drop of colored liquid (azobenzene dissolved in petroleum) communicates on the one hand with A, and on the other with C, by means of a capillary tube, *h*. By moving the reservoir, E, and finally (after closing the cock, *d*) the screw, *e*, the level of mercury in A is adjusted, so that the drop of liquid in the gauge remains at zero. In this way, as the air in A and C is shut off from outside throughout the experiment, and as the temperature is maintained constant by means of the water in the surrounding vessel, temperature and pressure may be neglected. The correction for saturation of the air with moisture may also be neglected. In the analysis three operations are necessary: 1. Air is drawn in by adjusting the mercury level to zero on the scale. The cocks, *f*, *g*, *b*, *c*, *d*, are closed. 2. The cocks, *d* and *b*, are



opened, *a* is closed, and the air driven into A from B. In one or two minutes the CO_2 is absorbed; the air is passed back into A, *b* is closed, *a* opened, and the mercury level in A adjusted so that the index of the gauge is normal. The diminution in volume is then read off on the scale.—*O. Petterson and A. Palmquist. Ber.* [illegible] 2129–2134.—*Jour. Soc. Chem. Industry.*

CELLULOSE FOR FININGS.

CELLULOSE, in the form of paper and wood pulp, is now being extensively employed on the Continent for the clarifying or "fining" of beer, wines, sirups, and pharmaceutical extracts. A little salicylic acid added to the pulp enables it to be kept in the flocculent or damp state without fear of decomposition. This salicylic cellulose seems to answer very well, and its popularity, accordingly, is rapidly increasing on either side of the Rhine.

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